REPORT RESUMES

ED 019 181 RE 001 199

READING MACHINES FOR THE BLIND.

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VETERANS ADMINISTRATION, WASHINGTON, D.C.

REPORT NUMBER VA-R-660127 PUB DATE JAN 66

EDRS PRICE MF-$0.50 HC-$3.04 74P.

DESCRIPTORS- *READING, *BLIND, *SENSORY AIDS, BRAILLE, TALKING BOOKS, VISUALLY HANDICAPPED,

AT A TECHNICAL SESSION, SIXTY-ONE PARTICIPANTS FROM THE FIELDS OF EDUCATION, INDUSTRY, GOVERNMENT, AND AGENCIES OF THE BLIND DISCUSSED RECENT DEVELOPMENTS IN THE PRODUCTION AND USE OF READING MACHINES WHICH PERMIT BLIND PERSONS GREATER INDEPENDENCE IN READING THE PRINTED PAGE. THEY ALSO EXPLORED PROBLEMS INHERENT IN THESE EFFORTS AND PROPOSED SOLUTIONS. THE BLIND CAN OBTAIN INFORMATION FROM THE PRINTED PAGE THROUGH SUCH DEVICES AS HIGH-POWERED LENSES, BRAILLE, RECORDINGS, AND SIGHTED READERS. OTHER DEVELOPMENTS DISCUSSED AT THIS SESSION WERE THE OPTICAL PROBE, THE OPTOPHONE, COMPUTER-REPRODUCED BRAILLE, SPELLED-SPEECH, RECOGNITION MACHINES, AND THE USE OF THE SERVICES OF THE TELEPHONE NETWORK. THESE DEVICES ENABLE THE BLIND TO TYPE AND READ THEIR OWN TYPING, TO IDENTIFY CURRENCY, TO READ CORRESPONDENCE, TO IDENTIFY LABELS ON PACKAGED AND CANNED GOODS, AND TO PERFORM OTHER TASKS WHICH REQUIRE READING. A LIST OF REFERENCES ON READING MACHINES AND THE BLIND IS PROVIDED. THIS IS A SUMMARY OF THE SIXTH TECHNICAL SESSION ON READING MACHINES FOR THE BLIND HELD BY THE VETERANS ADMINISTRATION (WASHINGTON, JANUARY 27-28, 1966). (NS)

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R-660127

SUMMARY

Sixth Technical Session
on

READING MACHINES FOR THE BLIND

Held at Veterans Administration Central Office
Washington, D.C.

January 27-28, 1966

1930

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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P-617 3/66

FOREWORD

These notes, somewhat delayed in preparation and duplication by the demands on our time of more urgent projects, constitute the most detailed public record of the proceedings of the Sixth Technical Session on Reading Machines for the Blind. A very brief summary of the same materials may be found in:

> Freiberger, H., and E. F. Murphy, "Reading Machines for the Blind," Science, Vol. 152, No. 3722, pp. 679-680, April 29, 1966.

A more extensive summary article on the conference will be found in:

> Freiberger, H., "The Sixth Technical Conference on Reading Machines for the Blind," Bulletin of Prosthetics Research, BPR 10-5, Spring 1966, Department of Medicine and Surgery, Veterans Administration, pp. 8-24, October 1966 /Available while the supply lasts from Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402, cost 65 cents./

Howard Freiberger

HOWARD FREIBERGER
New York, N.Y. 10001
February 26, 1968

Since the Sixth Conference several steps have been taken by various individuals, agencies, and sponsors. St. Dunstan's, the organization for British war-blinded, held a week-long International Conference on Sensory Devices for the Blind in June 1966; proceedings were published. The Subcommittee on Sensory Aids, National Research Council, held a symposium March 30-31, 1967; a report, now in draft form, probably soon will be issued in the Numbered Report Series. Hadley School for the Blind is developing a tape-recorded home-study course as an introduction to the Mauch Visotoner, primarily to help select candidates best suited to personalized instruction such as Mr. Lauer is now providing at Hines VA Hospital. Thirty Visotoner and ten Visotactor B reading aids, with accessories, have been ordered. Considerable activity at many centers on mechanization of braille production was reviewed at a conference at American Printing House for the Blind, Louisville, Kentucky, Feb. 8-9, 1968.

Eugene F. Murphy

EUGENE F. MURPHY, Ph.D.

TABLE OF CONTENTS

Page

Foreword

I. List of Participants
II. Introduction and Historical 1
III. Opening Remarks and Welcome 2
IV. Single Channel Devices 2
V. Direct Translation Machines 6
VI. Visual Effects Through Stimulation of Remaining Parts of the Visual System 25
VII. Intermediate Machines 26
VIII. Other Systems of "Reading" for the Blind 28
IX. Output/Display Systems 30
X. Recognition Machines 39
XI. Use of the Telephone Network 47
XII. Recommended Projects and Priorities 50
XIII. Adjournment 52
XIV. References 53

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THE SIXTH TECHNICAL SESSION ON READING MACHINES FOR THE BLIND

Washington, D.C.
January 27-28, 1966

II. INTRODUCTION AND HISTORICAL

Even though much of the nation was bogged down with heavy snowstorms, 61 persons attended the Sixth Technical Session on Reading Machines for the Blind held January 27-28, 1966 in Conference Room 119 at the Veterans Administration (VA) Central Office, Vermont Avenue at "H" Street, N.W. Washington, D.C. 20420. It is estimated the attendance was down about 30% as a result of the storms. Tabulating the current affiliations of the participants shows that 17 were from the world of education, 15 from industry, 14 from agencies for the blind, 13 from government (VA-7, NIH-2, VRA-1, LC-1, USN-1, NBS-1), one from NAS-NRC, and one a private practicing ophthalmologist. Professor Thomas A. Benham of the Department of Engineering at Haverford College, Haverford, Pa., served as chairman as he has done so many times before at earlier conferences in the series. The six VA-arranged conferences on reading machines held to date are:

CONFERENCE NO.	DATE(S)	LOCATION	NUMBER OF PARTICIPANTS
1	Aug. 20, 1954	Commodore Perry Hotel Toledo, Ohio	11
2	Apr. 25, 1955	Franklin Institute Philadelphia, Pa.	24
3	Aug. 3, 1955	Rockefeller Institute New York, N.Y.	38
4	Aug. 23-24, 1956	Veterans Administration Washington, D.C.	50
5	Sep. 17, 1958	National Academy of Sciences Washington, D.C.	68
6	Jan. 27-28, 1966	Veterans Administration Washington, D.C.	*61

*Note that more were expected, but some could not attend because of the snow storms.

Although there is a gap of over seven years between the fifth and sixth conferences, certain other meetings arranged under different auspices were held in that period and have served some of the same information-exchange purposes. Among these are the Human Factors Society Sensory Extensions Symposium, Cambridge, Mass., Sep. 12, 1960, the ONR-NBS Symposium on Optical Character Recognition, Washington, D.C., Jan. 15-17, 1962 (1), the International Congress on Technology and Blindness, New York, June 18-22, 1962 (2), and the ONR-AO Symposium on Optical Processing of Information, Washington, D.C., Oct. 23-24, 1962 (3).

III. OPENING REMARKS AND WELCOME

Dr. Eugene F. Murphy called the group to order at 9:20 AM January 27, 1966 welcomed those assembled, and noted particularly the presence of Drs. Werner and Nye who came through the snows from Germany and California respectively. Dr. Robert E. Stewart, representing the Chief Medical Director of the VA formally welcomed the participants and then turned the meeting over to the chairman, Professor Thomas A. Benham. He, in turn, briefly outlined reading-machine history of the past 20 years mentioning the RCA A-2 device (4), the RCA recognition machine (5), and the fact that many other more recent developments would be covered in the talks to follow. He referred to the school of thought which proposes that independent reading of a printed page by a blind person even at a speed of one word per minute is better than none at all. This relates to the value of being able to read a few words without assistance, perhaps to identify a document, to be alerted to the general contents of an envelope or book, or to scan items most people like to keep confidential, e.g., financial statements.

Dr. Murphy indicated that minutes of earlier conferences in this series hav been prepared, and that this Sixth Session will be similarly documented.

IV. SINGLE CHANNEL DEVICES

Mr. Leo M. Levens spoke on the "Optical Probe With Audible Output." He first quoted from Mr. A. Wexler (6) of Melbourne, Australia, a distinguishe teacher of science to blind students: "By means of photo-electric cells coupled electrically to sound-emitting apparatus or to vibrators, a great variety of phenomena normally observed by sight can be made perceptually accessible to the blind or if need be to the deaf blind."

Mr. Levens then went on to say one of the instructors first to make use of this principle was Dr. E. J. Waterhouse of Perkins School for the Blind. He used a photoelectric cell and buzzer in 1938 to enable his blind student to determine the altitude of the sun.

While the optical probe is not a new device, few people seem to know very much about it. This is evidenced by the fact that it is re-invented periodically. The probe seems to be a logical combination of a set of elements. It appears to fill a need. When it "sees" light, it emits sound.

The optical probe has been conceived independently by a number of inventors. Designers, in most cases not cognizant of earlier work in this field, devised instruments very similar to others already known.

A set of devices recently developed and constructed by a Princeton physics professor for use by his blind students is remarkably similar to devices in use in Russia and Australia and to those developed at the American Foundation for the Blind. The professor regretted that he was unable to draw on experiences of others but had to repeat their experiments. This is one of the reasons detailed information on probes is being presented here. Mr. Levens then described the device in some of its forms, listed some of its capabilities, and demonstrated four forms of the optical probe.

The optical probe is a device that responds to incident light and produces an audible output signal. It usually takes a form similar to a penlight. In its most basic configuration it consists of a light sensing element, an electronic audio frequency generator controlled by the light sensor and an audible sound reproducer such as an earphone or loudspeaker. A battery usually supplies the required power. The device functions in this manner. The lens gathers light and focuses it on the photocell which in turn supplies the necessary signal voltage to the electronics which controls the tone generator and causes it to produce as its final output a voltage sufficient to drive an earphone. Variations in the amount of light incident on the photocell result in varying pitches of the audible note in the earphone. Light incident on the probe, may be from a direct source or reflected. The probe is basically very simple but as one blind person said, after using one of the probes for a time: "The information gained with this device is rather small; however it is infinitely better than nothing at all, and, until now there has been nothing on the market...."

Specific optical probes have been constructed with additions and modifications to the basic design. These variants generally involve differences in input devices, light sensors, electronic detectors, power supplies, or output devices.

INPUT DEVICES include lenses; light transmitting fibers, rods, and tubes; illuminators; color and polarizing filters; choppers; and orifices or irises. These form the probe's front end.

LIGHT SENSORS include light-sensitive resistors, diodes, transistors, photovoltaic cells, light activated switches and other light sensitive electronic components. The sensors are chosen for spectral response, electrical output, size, reliability and ruggedness.

ELECTRONIC DETECTORS include simple tone generators, variable frequency oscillators or multivibrators, variable amplitude oscillators, bridges and potentiometers.

POWER SUPPLIES - These are usually batteries, primary or rechargeable. For fixed applications power lines are sometimes used.

OUTPUT DEVICES are generally earphones, miniature loudspeakers, or "Sonalert" units (commercially available combined oscillator and sound reproducing means).

The sensing portion of the probe may be mechanically mounted to "read" a specific indication such as the mercury in a thermometer or the needle in a compass. The probe may be mounted to scan a portion of a circle such as a meter or gage scale. It may be mounted so as to make a linear scan possible. Reference points can be provided in order to locate accurately points of interest.

Some of the capabilities of the device, by no means an all inclusive catalog, are as follows:

> Astronomical measurements of the sun and moon are possible when the probe is suitably mounted and provided with a telescope front end.
>
> Blind typists can orient letterheads and find margins.
>
> A blind telephone switchboard operator can use the probe to locate lighted lamps and thus operate the board.
>
> Colors can be matched by use of suitable filters and an aural potentiometer output device such as the audio circuit analyzer. Urinalysis is possible with this set-up. This is important to the blind diabetic.

Numerous scientific experiments are possible including many associated with the study of light and optics.

Meters and gages as well as mercury thermometers and barometers may be read. Compass directions may be determined. Horizontal level may be established.

Motion may be observed and measured. Rotational velocity may be established by measuring the output frequency produced by a reflective strip on a rotating shaft.

A radio repair technician wanted one of the devices to check pilot lights and stereo indicators in radio sets.

Simple diagrams and oscilloscope patterns may be traced.

Mr. Levens alluded briefly to the early work of Dr. C. M. Witcher (7) at AFB and MIT, which culminated in the production for AFB in 1957 of 45 "Audivis" probes by Dunn Engineering Associates, Cambridge, Massachusetts, at a reported cost of $35 each. He also referred to the devices of Messrs. A. Wexler (6), R. S. Muratov (8), and S. L. Bellinger and Dr. I. Browning (9).

Mr. Levens demonstrated several optical probes including one fitted to a hand-held boy scout's compass. Professor Benham also showed a 3" x 3" x ½" optical probe built by Mr. James Swail of the Radio and Electrical Engineering Division, National Research Council of Canada, Ottawa, Canada. Professor Mann mentioned related MIT students' theses (10), (11), but indicated the developments had never been carried through to a thorough user-trial phase.

In addition to the optical probe devices with tactile output mentioned by Professor Mann, Howard Freiberger briefly described suggestions in this area attributed to Drs. Heinz E. Kallmann (12) and Robert J. Moon. The Kallmann idea involved a photoelectrically controlled tactile stimulator at the end of a vibrating reed, this reed itself mounted orthogonally on a second vibrating reed. As the unit passed over black on a page the two reeds would be driven electrically to vibrate, causing the stimulator tip and photosensitive exploratory tip to describe a small rectangle. Sensed with the finger tip, vertical vibration of the stimulator reed as it swept out a horizontal rectangle would be the indication of black on the page below. The rectangular scan area is about the equivalent of a braille cell in size. The unit could be used to render printed braille tangible.

The Moon idea contemplated a photosensitive element carried at the finger tip by a glove or cuff arrangement, and a tactile "pincher" or stimulator on the same finger tip. The power and electronics could be on the hand or elsewhere, connected by fine wires. If the finger so equipped were scanned over a page a tactile signal would be received at the scanning finger tip whenever it passed over black.

Mr. Hathaway said Dr. Moon also suggested a four-channel probe with four photocells in a linear array controlling finger-tip stimulators on four adjacent fingers. Such a device could provide the illusion of drawing the fingers over large letters in relief. Mr. Mauch pointed out the similarity between this concept and that underlying his Visotactor.

Professor Benham mentioned another probe built by Mr. Swail having electrical stimulation as output. The intensity of stimulation is controlled by the user. Of 50 trial users some do not care for the unit, others have mixed reactions to the type of stimulation. Professor Benham demonstrated the device, gave instructions as to its adjustment and use, and then passed it among those present for personal trial.

V. DIRECT TRANSLATION MACHINES

Dr. Murphy made brief introductory remarks prior to the playing of a tape prepared by Miss Mary Jameson of London, England, who was not present at the conference. Miss Jameson's topic was "The Optophone: Its Beginning and Development." In the talk, reproduced below as submitted, except for the addition of some references, Miss Jameson tells of her 48 years' experience with the optophone:

TRANSCRIPTION OF RECORDING MADE BY MISS M. JAMESON. January, 1966

This is Mary Jameson speaking from London about the Optophone, its beginning and its development.

I first met with the Optophone in 1917 when I was 13 years old. I learned what was then the Optophone Code on an instrument built in the inventor's laboratory. This Optophone had one selenium cell which received light reflected from the printed page being read. White paper emitted a full musical chord; the reading was done by the tones blotted out by the black print as the scanner passed along the line.

In a word, reading was effected by what one didn't hear. This was not easy, and the frail construction of the instrument added to one's difficulties. The focussing arrangements would slip out of place if anyone walked heavily across the room. However, by August, 1918 I could manage a speed of about a word a minute, sufficient to shew that print reading was possible. At this moment, a most fortunate event occurred. Admiral Sir Reginald Deighton attended a demonstration given by me at King's College, London and he introduced the Optophone to Messrs. Barr and Stroud of Glasgow, who agreed to manufacture it (13). The Optophone when manufactured shewed a threefold advance; it was no longer frail to handle; the scanner was equipped with an excellent driving mechanism; and a second selenium cell, a balancer, had been added, so that the printed letter signals came from the black print and not from the white paper.

The British Optophone still uses the Barr and Stroud driving mechanism. It provides a rhythmic flow of signals which can be varied in speed by turning a screw. At the same time it can be held up by hand pressure if one needs to study a signal in detail. If only the selenium cells had been suited to their purpose as this drive was, the Optophone would have been of immediate practical use.

The volume of sound given by these cells was uncomfortably low, and they were apt to crackle after an hour or two's use. Yet the work on the balancer cell principle was not wasted, but was applied by St. Dunstan's when, twenty years later, in 1944, they took up the Optophone and substituted two photoelectric cells for the two selenium cells.

The new cells gave really adequate volume of sound, and after microphonic and focussing difficulties had been overcome, provided a useful instrument. Later, in the 1950's Mr. W. K. Hill became interested in the Optophone. His work on the focussing arrangements has markedly improved the definition of the output and made it easier to distinguish between shapes as similar as lower case 'b' and 'h' and 'i' and 'e'.

There remained, and still remains a serious drawback to the British optophone output: the signals are not heard against a silent background as they are in the case of the Battelle instrument (14).

Having reached the 1960's may I sum up the position as I see it. I think a driving mechanism with the attributes of the British system makes for ease and speed of reading. This should also be said for a silent background to the signals.

It is possible that further study will shew that the British Optophone gives better definition than the Battelle in the presentation of its signals.

Regarding tracking, one of the Battelle probes was fitted into the British scanner so that it could be operated with the British drive. This allows a rhythmic flow along the printed line, maintained at a speed desired by the reader. A turn of a screw increases or decreases this speed. /I will illustrate this point using upper case 'V' and 'W'. Each letter will be heard three times and the recording is made direct from the Battelle Optophone./

Normally I run the scanner a little faster than the rate at which I can pick up every detail of each signal, relying on hand pressure to slow up my reading if necessary. /I will now illustrate this./

Regarding definition, or the clear cut presentation of the signals, I find the British Optophone somewhat superior in this respect to the Battelle, in spite of background noise. As this is most evident when letters follow each other closely in words, I will try to illustrate the point by recording the title, "The Man, the Boy and the Donkey", from the Battelle lesson material, first on the Battelle and then on the British Optophone.

Mr. Hill thinks the image reaching the print from the British Optophone scanner is slightly narrower horizontally than that from the Battelle and this has to do with the sharper output from the British Optophone.

Coming now to the teaching of Optophone reading, I prefer the letter-word to the word-letter approach. The correspondence between the shapes and sounds of the signals is such a powerful aid to the memory besides stimulating immediate interest. For example, having told the student that every vertical line produces a chord, he quickly grasps that lower case 'm' having three vertical strokes has three chords; he will realise for himself that 'n' must have two.

I have said I prefer the letter-word method, and that is true basically, but I would rather call it the "letter and word" method because I would gradually introduce words as the student progressed with the letters. I would start with two-letter words, building up to words of about five letters. In this way I would construct a bridge between separate letters and instructional materials such as are found in the VA-Battelle 200-hour training course.

Also, with modern amplifying equipment I would not think instruction on tape records necessary, but would take the output directly from the Optophone.

This system would permit varying reading material and speed of presentation according to the speed of the students and the interests of the experimenter.

In the past I have had to move from an alphabet sheet of separate letters to a childs' primer having words of four, five and even six letters and I think the jump is too great.

I know that the word-letter method is used satisfactorily for teaching students to read with their eyes, but doesn't the situation differ from that of aural readers? The eye can take in at a glance a considerably greater range of characters than the ear, in fact the ear receives them one by one.

Being able to run the drive at a speed greater than that at which every detail can be picked up does help to speed the reading, however. Concerning the use of context, I cannot feel that this should be deliberately taught. It is often far easier to read the text than to guess at or think out what is likely to be ahead. Also, it seems to me that nothing should deflect us readers from performing what is still the basic task of helping the experts to discover the clearest possible code and the best manner of presenting it. Nevertheless, in practice one becomes familiar with the style and vocabulary being met with in the work being read and one can move quickly past names and other words which have become familiar.

I had hoped to include a sample demonstration of the Battelle output using the British scale, but it does not seem to suit the Battelle Optophone, the frequencies needed for wavy letters such as 'v' and 'w' seem to be too close. Where these letters narrow to a point a merging and roughening of the tones is caused. Mr. Hill has cured the trouble by spacing out the six tones. Although this situation does not allow me to attempt a fair comparison between the Battelle and the British scales, I thought it might be useful to try comparing a six tone with a nine tone scale. For this I recorded the words 'winter' and 'snow' from Battelle instruction tape recording No. 15, then recorded the same words direct from the Battelle machine I have here. As so often happens in this kind of work, I met with a snag; the general quality of the instruction tape recording is much clearer than from the Battelle used by me.

In this short survey I have tried to do three things. To indicate the value of the British-type drive; to illustrate the advantage of the Battelle quiet background, and to suggest the direction which it seems to me that further research should take with the object of improving the clarity of the output. Vertically speaking the best number and choice of tones, horizontally speaking for the clearest possible definition.

When I have recovered from the operation for which I enter hospital on 12th January, I hope to resume my studies. In the meantime, may I wish this Conference the success its importance deserves.

Professor Benham inquired whether all present knew enough about the design and construction of optophone systems such as the one built by Battelle Memorial Institute to understand those parts of the conference treating of these devices. Mr. Freiberger described the Battelle system as an optical to audible transformation mechanism wherein the disposistion of ink on the printed page as alphanumeric characters in the y and x directions is transformed to on-off combinations of nine discrete audible tones in a frequency (pitch) and time domain. The frequency dimension is related to where "black" exists in a narrow vertical slit-like section of the letter being examined, higher frequencies for "black" relatively higher in the section, while the time dimension relates to horizontal position as the letters and in turn words and lines are scanned from left to right.

Mr. Freiberger, a VA staff electronics engineer, then told of his experiences using the Battelle 200-hour optophone training course with Mrs. Geneva Washington, a blind social worker who has volunteered to take the lessons in spare moments. Despite the severe pedagogical shortcomings of such an informal arrangement, the subject had reached the 80th lesson by the time of the conference with performance about the same as the average at Battelle Memorial Institute during their more intensive controlled learning study. Original plans for this volunteer arrangement between two VA staff members called for completing three hour-long lessons per week. Because of competing official and personal activities of both instructor and student, holidays, illness and other mishaps, the three-hour per week schedule could seldom be maintained. Some quantitative data resulting from this effort are given in Table I.

Professor Benham noted that reading speeds reported for optophone users are not very high, but he pointed out that adults are the subjects. He repeated a question often raised about what the results would be if children were introduced to the optophone and given as extensive and lengthy training and practice as sighted children get when learning to read. Mr. Freiberger mentioned the resistance some educators feel to taking a child and subjecting it to optophone training at the expense of giving tried and tested training in braille and other subjects in the relatively few hours of the school day. At Battelle Memorial Institute some work had been done with both grade school and high school children. The younger children seemed to have trouble with some of the mechanical tasks associated with use of the optophone as it then existed, and psychologists felt that the high school group was in the wrong age bracket for teaching the skill.

Dr. Leo H. Riley then summarized the experience with the optophone at ACRIBAR. The approach was to select subjects thought to be highly motivated, persons who had expressed a desire to be able to read inkprint, and who felt a loss at being unable. Screening of prospective subjects was done in December 1964, including tests of physical fitness, I.Q., hearing, psychological adjustment, performance on tests prepared by Battelle as possible selection means, and musical ability using Seashore materials. Six subjects were selected, three males and three females, ranging in age from 29 to 49, with I.Q. range from 110 to 141. Instruction began in January 1965 using the Battelle training program. At ACRIBAR a little more time per lesson was taken at the start than recommended by Battelle, but after the first few weeks of instruction it was found possible to exceed the lesson rate of the curriculum. Some problems arose such as improper instrument operation at the start. This was corrected and no further instrument troubles occurred. The tracking boards also had mechanical defects which were troublesome. There was a discrepancy between sounds of the code from the uniformly paced tapes and hand-tracked Model D instrument. As tracking skills improved this trouble was of less and less concern. Personnel problems developed in that four of the original six selectees left the program when they got regular employment, one more left temporarily to take a short-term job in another city, and the sixth had to suspend attendance because of fairly serious illness. The best course for the future seems to be use of evening and week-end time for training sessions rather than prime daytime work-hours time. In spite of these setbacks the two subjects who remained longest achieved reading speeds with the course materials of 7.1 words per minute after 35 lessons (October 1965) and 4.5 wpm after 66 lessons (September 1965) respectively. Additional details of this work may be found in (15) and (16).

Mr. Harvey L. Lauer then presented his paper:

QUANTITATIVE DATA ON TRAINING A VOLUNTEER ON THE VA-BATTELLE OPTOPHONE

1. Date (Commence 01-14-64)	05-04-64	07-31-64	10-12-64	12-31-64	03-08-65	04-29-65	08-11-65	01-21-66
2. Elapsed Time Between Tests (Weeks)	15	12	10	11	13	08	14	23
3. Lessons Completed Per Week	0.7	0.8	1.0	0.9	0.8	1.3	0.7	0.4
4. Test No. (Level)	I(PP)	II(PP)	III(PP)	IV(1)	V(1)	VI(1)	VII(1)	VIII(2)
5. Reading Speed (wpm) (less line change time)	2.8	2.9	3.4	2.9	4.8	7.0	4.4	3.4
6. Reading Speed (wpm) (including line change)	2.3	2.5	3.0	2.7	4.2	6.5	3.9	3.1
7. Time to change line (min/line)	0.75	0.75	0.47	0.31	0.36	0.15	0.33	0.44

(PP) indicates pre-primer level text
(1) " first grade material
(2) " second " "

TABLE 1

POTENTIAL USES OF THE OPTOPHONE

My neighbors are saying I have come to Washington to testify about the Optophone, and I suppose they are right.

By discussing the uses to which I have put an Optophone, I plan to show how this method of reading ink-print may become an efficient tool for many blind people.

I work for the Veterans Administration teaching braille to blind and visually impaired veterans at Hines Hospital in Illinois. Formerly, I was a home teacher for the state of Illinois.

I took the 200-lesson course of training for use of the Optophone. Both the course and the Optophone I used were developed for the V.A. at Battelle Memorial Institute in Columbus, Ohio. As yet, I have not taught the skill.

The course was completed about a year ago and since then, I have used the Optophone for many little things.

I always read alone, but I had help in selecting the materials of the course, taking tests, etc.

After completing the course, a four-step procedure was evolved for developing new uses. The procedure could be terminated in success or failure at any point. Step one is to try to read or identify an item. Step two is to have someone describe the material, and I would ask him pertinent questions about it. Then, if step three were needed, I would re-examine the item using the Optophone. In some cases step four was helpful. I would make a braille description of the format of the reading matter so that I could efficiently read a similar item in the future. In the case of some items like bank statements, I could simply remember the layout.

I do not claim maximum efficiency for this procedure, and it should be modified for some learners of differing abilities and backgrounds.

I found six categories of efficient uses for the Optophone. A few months ago there were four, and the sub-groups are increasing each week. A pleasant surprise awaits me around every other corner. The job of reading something for the first time more than offsets the imminent little failures along the way.

It remains to define an efficient use. An efficient use is one which, after reasonable training, permits greater independence and also reduces the handicap of blindness to the individuals under consideration. I am here concerned with the things a busy person would want to read himself with a machine like the Optophone.

1. Of great importance is the ability to read one's typing and to check the operation of a pen or pencil, or determine if an ink stamp has printed or not. I did this long before completing the course. It was made easier because of the foreknowledge one has of what is being read and because the likely typing errors are unlikely to be missed with the Optophone. I spot-check correspondence and read all addresses and checks I write. I occasionally find an error I had no idea was present. I can read with the paper still in the machine if necessary, make corrections with all-white carbon, find my place or read what was last written. I sometimes write several checks and envelopes and then check them all. At first, it was more efficient to check an item immediately after writing it.

Formerly, our typewriter would quit working properly in the midst of a stack of Christmas cards. Now, even the slightest question as to a key struck or an item inserted into its proper envelope can be cleared up on the spot. I used raised-line checks and type them all. There is no longer the need to carry around letters and checks just to have the typing checked. My typing is improving because I can concentrate more on accuracy and because those strike-overs sound terrible.

There are those who, through carelessness or desperation, do not have their typing checked. They sometimes send blank or unsigned checks through the mail. This calls for attitude development.

A blind typist using the Optophone would not need sighted help in making corrections and could even replace the paper into the typewriter when necessary. When a blind person has much detailed work to do, sighted family members can become discouraged. As a college student, I would often wonder, "Let's see, whom should I pester with this problem?"

2. The second category is identification of currency. I identify $1, $5, $10 and $20 bills. This can be done with one hundred per cent accuracy with either the Battelle instrument or the new Visotoner developed by Mauch Laboratories. The Visotoner is better for this purpose because one can scan an area almost one-half inch tall and because it is so compact and portable. Identifying money is often more necessary away from home.

Perhaps a businessman such as a vending stand operator might keep the device on a bracket within easy reach. I believe it would add to the confidence of his customers in a blind businessman if they knew that he could identify money himself when necessary. Of course, one should still use a good system of filing currency. Incidentally, blind parents would like to have their own independent means of identifying currency.

3. The third category is reading correspondence, memos, bulletins, newsletters, etc. Handwriting cannot be read with the Optophone so far as we know. It is a great pleasure and very handy to read a typed note from a friend or to read a letter from Mr. Freiberger about reading machines. In order to avail myself of that privilege, I will gladly read a carbon or thermofax copy.

Even those correspondents who do not type may want to locate a typewriter and tap out a private note.

4. The fourth category is reading many bills, checks and bank statements, familiar forms, etc. I learn the layout of my common bills and make braille notes about them if necessary. For example, I read and copied the entire form of my machine-printed Earnings and Leave Statement. That was very hard to do, but now I can locate the information I want from subsequent statements in a minute.

Reading bank statements has become very routine. I can either read all the figures from the statement or else read all the checks and only a few figures from the statement. An abacus helps with the necessary calculation.

For many of my bills the cycle is now complete. I read the bill, record it in braille, write the check, read it over and mail it. Then when I receive my cancelled checks and statement, I read and take notes on it.

Here again attitudes toward responsibility and independence play a role. Some blind people pay their bills in person without having them checked. I know a blind person who paid his neighbor's electric bill. Some blind people simply discard all unsealed mail and anything that feels like an ad. If that were the policy at our house, some neighbors would be unhappy because some of their mail is mistakenly left in our mailbox.

5. A fifth use is to identify mail, packaged goods, canned goods, etc. Identification is usually more urgent than reading. I know blind people who will buttonhole everyone who comes to their door to get things read or identified. Return addresses are often easy to read with the Optophone. One can read bits of ads and discard them at will. I braille the envelopes of items I have identified. Experience shows us that it is often expedient to censor items which a particular reader would not like to read. This may include religious and political material.

There are several hidden advantages to identifying things oneself:

A. The time of a sighted reader may be better used for reading more lengthy materials. B. Items do not need to be moved or carried around too much, so they are easier to keep track of. C. It reduces the urgency of getting mail read and makes for a more flexible schedule.

Recently I have been gratified to find it easy to read labels on canned goods and cartons. I began to read recipes and directions also. Braille and orderliness reduce the amount you need to read. For example, with careful buying and study of features on cans, one needs to read less than one-third of the cans with the machine. Then all of the cans can be labeled if desired, The new Visotoner works much better for this work because much larger print can be read with it. Those big letters on TV dinner cartons and cereal boxes stand right out for the Visotoner. It is also easier to change adjustment for the size of type read, and it is easier to "roll around a can" with the Visotoner. I took the Visotoner into a supermarket and read some labels with it, and I feel that it may become practical to use it in some situations like this. The area of identification is quite new to me. I am looking for suggestions; much more may be possible in this area.

Much of what I have said shows how the Optophone complements other skills, namely, braille, typing and language skills. Orderliness aids in making its use efficient. The same can be said for the use of sighted readers.

6. I use the Optophone for all I have mentioned thus far, but there is a sixth category I plan to work on--reference books. Braille is too bulky to permit most people to own a good dictionary or reference work. The ability to use such texts in a library would be even more important. I have read the print in some of these books but have not tried to look things up as yet. Children's reference books may be a help here. Again the Visotoner, because of its shape, portability and easy-to-use controls should be a great help. It also has a good feature for reading italicized print. The photocell array can be rotated so that the "slanted" print sounds almost like ordinary print to the ear.

I have also had a brief chance to use the Colineator which is the tracking board developed by Mauch Laboratories of Dayton, Ohio. It is marvelous and very versatile. It should help with reading books. I even enjoyed using it by using the Battelle probe against the bar of the Colineator.

There are other uses for Optophones which are as yet inefficient. Nevertheless, some people may want to read magazine articles, case records, and even whole books with the instrument. My plan is to read magazine articles in order to build speed. A new motor-driven pacing aid has been built. We want to see if steady motion of the probe will aid in developing speed. This seems to have been the case for some other learners. Perhaps magazine articles will be very practical.

I made some mistakes which slowed my progress along the way. First, although I enjoyed reading articles and stories, I stopped reading them too soon, so my reading speed did not have a chance to increase. I tell my braille students to read magazines for practice after completing the course, but I did not practice what I preach. The second mistake was that when I first began to use the machine at home, I did not keep it handy enough. The machine should be available to use momentarily. The biggest problem has been the small amount of time I could devote to this work. A small problem has been some difficulty with the equipment.

Many questions are commonly asked of me. How fast do I read? I read from 5 to 25 words per minute depending on contrast, type font, context, and whether or not a tracking board is used.

Some say, "Who wants to read so slowly?" I feel that a number of people would like to do just that. Thousands of people use braille at very slow speeds. They use it for notes, addresses, and labels. Most learners of braille need to read a great deal after learning the skill in order to develop speed. This fact and my experience leads me to believe blind people may want to read some print slowly.

People also ask if it was difficult to learn. It was difficult, but some braille students work harder learning braille than I have had to do in learning the Optophone. People also want to know if I have extra ability. I suppose so, but it required extra ability under the circumstances of working alone and experimentally much of the time.

I believe that with a little better Optophone and improved teaching methods, this skill will be brought within the reach of many more blind people. I also believe that, like braille, this skill may best be taught by a person who uses the skill. In the case of a new skill like this, it may be even more important. A teacher must listen to the output of the machine part of the time and help the student trouble-shoot. In fact the teachers may need to learn to teach trouble-shooting, scanning and skimming if this is possible. By careful and experienced tutoring, we may be able to reduce the need for tape recordings.

We need to direct students to uses for the skill such as checking their typing at the appropriate time. I have kept samples of various kinds of print encountered in everyday use for this purpose.

We have found in teaching braille that if we introduce new uses for braille at the propitious time, motivation to "struggle on" is greatly enhanced. On the other hand, we can discourage a learner by giving him ill-timed tasks no matter how well the skill is taught.

I also feel that motivation will play a cardinal role in learning this skill, and it would be helpful if students could be promised the use of the machine if they mastered and used the skill. I hope that many a blind typist, professional worker, businessman and housewife will find this skill of benefit. Home teachers with whom I have spoken were especially enthusiastic when they heard how I used the machine. Short passages can be read as efficiently on an optophone as by a sighted neighbor where necessary arrival and departure social chitchat consume as much time as machine reading. Also some materials of a religious or political nature cause a reader to be uncomfortable, and embarrassment sets in for all concerned.

Much of what I have said here may apply to other "limited access" reading machines. Though the Optophone affords limited access to print, it has made me feel less limited.

I cannot begin to thank everyone who helped me. They include staff members at Hines Hospital and many of you gentlemen here at the Conference.

In summary, I love to use the Optophone. The pace is slow, the mileage is improving, but the payload is terrific. I would like very much to teach the skill.

Professor Benham then said that it was apparent to him from Mr. Lauer's remarks that a device of this type was useful even at the present stage to read short things, and even some more complicated documents. Mr. Smith said he has seen some of Mr. Lauer's versatility, and that he not only can read carbon copies of documents, but on one occasion read a "Thermofax" of a carbon copy.

Mr. Lauer mentioned the Visotoner several times during his talk. Professor Benham explained that this device was built by Mauch Laboratories and that Mr. Glendon Smith would speak next on the Visotoner.

Actual Visotoner hardware was started in April 1964 when the Visotactor design was also completed. It was felt optophone instruments might have better acceptance if they had some of the Visotactor features. A variable magnification scheme allows for accommodation of print from about small want-ad size to medium sized column heads, a five-fold range, with maximum limit at 0.440 inch. The frequencies used are as in the VA-Battelle optophone, 440 cps, 554, 698 and twice these frequencies, and four times, for a total of nine tones. Mr. Smith showed a slide of the unit, pointed out the optical barrel, the four finger rests (as required in the Visotactor), the illuminating lamps, battery, rollers, and lens. An internal view of the four components of the optical barrel was then shown. The photocell array developed at Mauch Laboratories was visible, as well as the cam-tube arrangement used to position both the lens and array such that sharp focus is maintained over the entire magnification range. The magnification adjustment knob has raised dots in the several "clock" positions to allow blind users to make direct settings if they happen to know the type size they intend to read. Another slide showed the assembled optical system. Mr. Smith pointed out that the single "sensitivity" control of the Visotoner operated through manual control of the lamp brightness. Such an adjustment is necessary as the amount of light falling on the cells depends on the magnification in use. The cells always "trigger" at the same level of illumination, in this case about three foot candles. If any cell senses less illumination than this, the corresponding tone is switched on. The body of the Visotoner contains all necessary components, some 38 silicon transistors, 63 resistors, 18 capacitors, and 12 diodes. A miniature hearing aid earpiece is used to deliver the audio output to the user. The entire unit may be carried in a small leather case slung over the shoulder somewhat as is done with a camera.

Professor Benham then introduced Mr. Loyal E. Apple who presented the following paper on:

FACTORS AFFECTING READING MACHINE INSTRUCTION IN REHABILITATION CENTERS

After watching the progress of Battelle Institute and Mauch Laboratories, my superior, Dr. W. T. Liberson, Chief of Physical Medicine and Rehabilitation Service at Veterans Administration Hospital, Hines, and I were pleased when it became possible for us to have one of the Battelle machines at Hines. Dr. Liberson's own interest in the application of electronic technology to the amelioration of physical disability was a factor in making this venture possible.

On May 13-17, 1963, Mrs. Genevieve N. Miller, Assistant Chief of the Central Rehabilitation Section for Visually Impaired and Blinded Veterans, went to Battelle Institute in Columbus, Ohio, for training which would fit her to instruct in the use of the machine. Mrs. Miller began the training of Harvey Lauer, Braille Therapist, in April, 1964. They proceeded through the two hundred lessons of the Battelle series as their working time would allow, until Mr. Lauer completed his instruction in December, 1964. In addition, Mr. Lauer put much of his own time and energy into the program and is to be highly commended. Mr. Lauer has presented his own experiences earlier in this session. I liked what he said and I detected that the group assembled here felt the same way.

The reading machine is not a substitute for braille reading and writing. Braille has qualities which make substitution very difficult. The reading machine is an additional communication tool and öffers great freedom in perceiving the ideas contained in the printed or typed word. Braille gives much greater flexibility in retrieving ideas that have been set down for the writer's use.

There are about five ways in which a blind person can obtain information from the printed word--high-powered lenses is one way for some legally blind people, braille, recordings, a sighted reader, or the optophone. All except the optophone and high-power lenses require the action of a second party. The optophone, however, will not be able to completely displace any one of the other four, for each has its invaluable aspects for the blind person.

There are factors which govern the adoption of new programs in the comprehensive rehabilitation program of the center at Hines. These apply also to reading machines. There are the factors of validity and relevance which must be considered first. After these come the factors which govern inclusion.

When a new program involves any device, it becomes important that the device has technical validity, and does what it is designed to do reliably. Portability, size, repairability and other factors important to engineers come into play and seem to be adequately met by the Battelle device.

There is a concept of validity of instruction which is not as clear-cut as I shall define it. Instructional validity has to do with human beings being able to learn to use the device with a reasonable amount of time and effort. The instruction series for the optophone seems to have been well validated. On the basis of the experience with Mr. Lauer, we would hypothesize that the actual time the instructor spends with the student might be reduced without serious harm to learning efficiency.

Relevance of both device and instructional program to the management of sight loss is important. The deepest motivation springs from participation in activities which promise the most success in managing the greatest areas of life affected by loss of sight. This is the way in which we would define relevancy. The device and the techniques, which are to be learned for its use, are always weighed in this manner. Indications are that the optophone has relevancy for some blind persons but is not universal in its applicability in solving the problems of blindness.

The factors governing inclusion of a device which has validity and relevance into an established program of proven worth are very complex. Inclusion may be made by displacement of a previously established program element, or by addition to the established schedule of the program. In order to displace a program element, the program to be included must answer the same difficulties of blindness in a better way than the element being displaced. That is, a mobility program can displace a mobility program or a counseling program can displace a counseling program if they have a higher relevancy. The optophone is an additional area of function and does not duplicate any of the established types of program and, therefore, could not displace them.

New programs can be included by addition to the established programs when there is a high level of relevancy and if the new program is for an area of function not touched by existing programs. Such additions do have an effect on participants as well as other phases of the program. The time, energy, and attention of participants can only be spread so far before some part of the program in which they are participating begins to be slighted. Motivating blind persons to expend energy at a high level is a part of the staff function in our center, but there are reasonable limits. Although there are negative factors, inclusion of the optophone program into the center should be by addition, rather than displacement.

If there were a very limited number of individuals with whom we would deal, an optophone program could be worked out with only a limited increase of the patients' stay in the section. This would have to be done by adding evening and weekend classes on the optophone and by some modification of the training regimen developed by Battelle Institute.

I do know of a center where substitution, or displacement of a sort, is a part of their programming, and which might include the optophone program by displacement. Perhaps both should be tried.

The kinds of knowledge and skill which are found in a blind rehabilitation center would provide an apparently promising environment in which student, instructor and machine might be brought together. A center might set up a specialized program for men who wished to be admitted specifically for training with the optophone, in much the same way that dog guide schools admit for only one area of study. Such an insular program, if significantly extended, would need additional space, equipment, and staff; but, it would more nearly meet the instruction time criteria developed by Battelle Institute. These time requirements are much longer than the time span usually occupied by the rehabilitation process.

Instruction on the machine might also be tried on a home visit basis, wherein the teacher instructs the prospective user in his home. The machine would stay in the home and the student might use it for practice at his convenience.

There is a factor which seems implicit in the development of the optophone. That is, that machines will be issued to blinded veterans who are satisfactorily trained in their use. This is a strong motivational factor. Blind persons who learn to use the machines must have some assurance that the optophone will be available to them after they have satisfactorily completed their training. It is hoped that blinded persons may seek out a skill with the optophone as a matter of intelligent self-interest, wherein after they learn to use the machine it will be available to them.

There are other human factors which are not clearly understood yet. These seem to be principally those of readiness. We will not understand these until we have spent some time earnestly training blind persons to use the optophone. Not all blind persons have a strong sense of urgency about learning to read a new way, but those who do, and especially those who have a practical use for such skill, should be able to do so.

The group went to lunch after Mr. Apple's paper, and on return Mr. Lauer gave a demonstration of reading using the Visotoner and Colineator, and then the VA-Battelle optophone, Model D. Pointing out he has used the Visotoner for only a week or so Mr. Lauer read from the multilithed list of names for those who had registered early for the Conference. The going was slow and rough, but he did read "J. Malvern Benjamin, Pres." and some other material on the sheet. Then Mr. Rotkin presented an advertisement for Mr. Lauer to read. Confident and cheerful, explaining as he went along, Mr. Lauer tried, but was not able easily to read this material with the Visotoner. Mr. Rotkin said it was a severe test having four different type sizes, some illustrations, and some "negative print," i.e., white letters in a dark background. It was agreed this was representative of what might come in the mail. Mr. Lauer then read more successfully from a Civil Service Commission document. Some months later as your editor was preparing this summary partially from tape recordings of the sessions, he attempted to get some measure of the reading capability demonstrated by Mr. Lauer. Keeping in mind that Mr. Lauer was not really hurrying, that he had interruptions from the group, and answered questions too, note that he read the following passage with the Visotoner in 3 minutes 50 seconds:

> calendar days after the effective date of the
> action taken as a result of the classification
> decision, whichever is later. This will assure
> any entitlement you may have to retroactive
> salary adjustment.

Roughly speaking this passage was read at a speed of 8 wpm. Mr. Lauer also read from the same document using the VA-Battelle optophone. He read the following materials in 2 minutes 46 seconds:

> description. If you do not have one ask your
> supervisor for it. It should be kept available

/interruption/

> or are given the task of preparing descriptions
> for others under your supervision.

These passages were read at a speed of 10 wpm. It must be emphasized that conditions, equipments, and techniques used at this time were not optimum for the realization of high reading speeds, nor was this in fact the goal of the demonstrator.

A discussion then ensued relating to the validity of using Seashore tests in selecting persons likely to succeed with the optophone. Drs. Nye, Riley, and Mallinson felt there was some relation between these tests, musical ability, and optophone performance, whereas Professor Metfessel and Oliver Selfridge had somewhat opposing views. Professor Metfessel said the 3.5 cps differences in the Seashore tests were so small compared with optophone note differences that he was not sure performance in one area was so closely related to that in the other. Mr. Selfridge said that the optophone noise is not music, the device is not a musical instrument, and references to music are irrelevant. Mr. Freiberger volunteered he feels motivation and need to read may be principal components in the makeup of successful users. Mr. Selfridge raised the question of the effect on performance of the uncertainty in a user's mind as to whether he would own and/or retain a machine after he put in hours of learning. Mr. Freiberger pointed out that while the ten Model D VA-Battelle optophones now extant were Veterans Administration property, no machine had ever been wrested away from a truly successful user, nor did he think such was anyone's intention. Mr. Selfridge pointed out there were many sound "channels' besides tones, e.g. clicks, buzzes, noises, trills, and transients. He continued, tones are probably the worst choice for conveying information. It is no accident that human languages depend mostly on cues other than tones, and where tones are involved the use is minimal. Mr. Freiberger mentioned early Battelle work, and Dr. Cooper spoke of the simulated tests done in the Committee on Sensory Devices (CSD) days (17). Superiority of other sounds than tones did not seem to be a finding of these limited studies. Mr. Mauch also told of some of his work with other sounds (18), (19), concluding that the closer to speech an output is, the better, but that complexity of auditory display alone is not the answer. Mr. Bledsoe recalled that in one of the earliest English dictionaries music was defined as the "lease unpleasant of noises," and he added the optophone sounds seemed pleasant to him. He also stressed the importance of relating research work to the blind at all stages as opposed to the idea of first producing a very good instrument and then working with blind people. Professor Mann concurred that evaluation with human users must be involved in the early stages of a device and right on through all later aspects of development. He also questioned the use of pure tones at the particular frequencies of the VA-Battelle instrument. Mr. Freiberger referred to the brief psychoacoustic tests which led Battelle to the present set of nine tones (20), (21), and pointed out that the British optophone used only six tones differing from the Battelle in frequencies and timbre. Dr. Ben White remarked one could simulate a great variety of outputs without building a machine by use of computer techniques. Dr. White further said that in evaluation studies of the optophone reading speed is essentially irrelevant. The measure should be something like how long it takes to find a telephone number in the book, or how long to complete miscellaneous lookup tasks of the types this instrument is likely to be used for.

Professor Benham then asked Dr. Murphy to speak on the subject of tactile outputs which he did by describing the Faximile Visagraph (22). Such an instrument serves the need of rendering into embossed relief form graphic materials such as drawings, charts, plans, and graphs. It is felt that the machine described, built in about 1946, is not as refined and useful as one would like to have it. More work seems necessary both in development of a practical machine and associated materials and techniques, and also in evaluation of the utility of essentially "unedited" tangible versions of graphical materials prepared for the sighted.

Professor Mann inquired of the group why a Gestetner process involving automatic preparation of a duplicating stencil from the graphic original, and then printing the stencil with a special ink which when heated for a few seconds produces a raised area. This could be used both for line drawings and braille materials. There was then a brief exchange between Professors Mann and Benham and Dr. Nye regarding ability of a blind person to use unedited graphical material made into tangible form. From his 30 years experience with these matters, Professor Benham indicated some editing seems to be useful, but he yielded to the others that definitive psychological analyses had not been made on the subject.

Professor Geldard then spoke of his work on the *optohapt. Mentioning ideas of J. J. Rousseau in 1762 and D. Katz and R. H. Gault in the first part of the twentieth century, he reminded the group of the lack of success of their attempts to convey music or speech to an individual by attaching some sort of hardware to the skin. Professor Geldard decided on a different approach. Why not "ask" the skin what sorts of discriminations it is capable of. It seems responsive in dimensions of amplitude, frequency, time, and locus. It is with this last parameter, locus, that engineering designers often "fly in the face" of the skin's ability by giving it sensory tasks it cannot accomplish. To "give the skin a chance" Professor Geldard favors spreading out multiple stimuli over as wide a skin area as possible. Symmetric points on the body should be avoided when placing stimulators. A recent paper (23) illustrates these ideas in some detail. Ten stimulators were placed on the body, and they were operated at a 15 db sensation level for 200 millisecond bursts separated by 2 second quiet periods. Paired patterns of likes and dislikes

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*At the meeting the term "optotact" was used, but subsequently, and prior to release of this summary, Professor Geldard, for reasons of etymological homogeneity changed the usage to "optohapt."

were presented and the subject indicated same or different. Data on discrimination of such vibratory patterns were thus gathered. It was not only the numbers of vibrators activated that counted, though the larger the number the harder to discriminate. "Communality" of successive patterns had a strong influence. In the work described so far all vibrators for a given pattern configuration were "on" or "off simultaneously for the entire 200 millisecond presentation interval. Noting that the skin is extraordinarily good on temporal discriminations, Professor Geldard also tried patterns where there were differences in the "on" and "off" times of the several stimulators during the pattern presentation interval. This test was instrumented by use of a nine-cell VA-Battelle optophone probe mounted so as to scan characters on a 30" IBM electric typewriter. A set of 36 symbols was selected for use in this experiment. After typing the desired symbol, the carriage movement caused the optophone probe to scan the symbol. The nine cells then controlled nine stimulators arranged on the body. The vibratory patterns resulting from this arrangement were thus spread out over the space of the body and also over the time of character scan. An analysis of data resulting from such experiments showed that letters are not well discriminated, suggesting this is not a good tactile output means for a reading machine for the blind. Symbols best discriminated, ranked in decreasing order of discriminability, are the period, quotation marks, a small solid square, the hyphen, equals sign, an arrow pointing to the right, the plus sign, the letter I, a small square in outline, the symbol π, the "greater than" sign, the slant or slash mark, a diamond shape, and the letter L. The next letter in this series is the "A" in 40th place (which serves to emphasize how poorly letters work out with this particular transform). The optohapt experiments were started with a presentation rate of 20 characters per minute, but this was increased to 70 per minute to give the characters a certain "zip." Professor Geldard concluded that the main lesson one can learn from these results is that the skin just doesn't like Euclid. There is no reason to think that visual symbols, evolved for use by the eye, are any good for use in systems employing the skin as end organ.

Professor Linvill spoke next on his work with direct-translation tactile-output reading machines (24). He felt that with new technological tools now available, this old idea could be profitably developed. He told of the tactile reading studies conducted at Stanford Research Institute (SRI) using a facsimile but enlarged representation of letter shapes made tangible by means of a dense array of piezoelectric-reed vibrators in a perforated finger-rest plate. Ninety-six reeds drive small stimulators arranged in a 12 x 8 array in the plate. The optical parts of a complete reading machine working on these principles have been simulated on a computer. An auxiliary 12 x 8 array of electric lamp bulbs can be used to show observers visually the condition of the tactile array at any time. Piezoelectric reeds are simple motors for the purpose, 1½" long, 20 mils thick, by 1/32" wide, operating as small-deflection resonant systems with about 95% efficiency. The skin is exquisitely sensitive to such vibrations if in the correct amplitude range. It can detect amplitudes of 1 micron, and 10 microns can be detected easily. Power to drive each reed is in the order of only 30 microwatts.

Three subjects, "reading" stylized computer-generated letters presented in an 8 x 5 matrix array, were getting 20 words correct per minute after 10 hours of learning. To explore a more practical question, a pica typewriter font, upper and lower case, was analysed by projecting images of the characters on an 8 x 5 array of squares and noting when half or more of any square was "black." The computer then produced signals to control the piezoelectric bimorph array based on the "black" squares. Ultimately the three young test subjects could read all the letter types tried, but there was a "horrible shock" noted as they readjusted from all upper case to lower case characters. Professor Linvill feels that training and practice beyond that already given will lead to definite improvements in reading capabilities.

Dr. Bliss, a colleague of Professor Linvill's not present at the meeting, was interested in the effects of displaying less than the full 5-column width of the characters. Degradations in performance to 90% with 3 columns, 80% with 2, and 20% with 1 column were noted.

Professor Linvill then showed a movie of his work made in the Summer of 1964. His daughter, Miss Candy Linvill, reads in the film. Since the time of the film her reading speed is reported as up to about 35 wpm.

Professor Linvill concluded by voicing agreement with Mr. Selfridge that research on the mechanisms of signal processing is needed. He now has some support for work in this area from NINDB.

The researchers at SRI are in the process of putting together a small-sized version of the reed-array reading machine. They realize there are a number of steps yet to go to reach a usable device. Professor Linvill is convinced reading speeds of at least 35 wpm will be achievable. Professor Linvill closed acknowledging the continuing valuable activities of his associate in this work, Dr. James C. Bliss of SRI.

Mr. Smith of Mauch Laboratories explained that the main machine under development there was a recognition machine having a spelled speech output of sounds supplied by Metfessel Laboratories. A user of such a machine, to find the line of print, to read characters not within the recognition capabilities of the circuits, and possibly to use independently of the main machine where pocket portability is essential, needs some auxiliary system. A tactile output, direct translation device called Visotactor was conceived to serve these purposes, and designated the Visotactor A. Because of the basic appeal of a small portable unit it was decided to construct one minus the photocell array needed as input for the recognition machine. This unit is designated Visotactor B (25). A linear array of eight cells is used in scanning the letters in a line of type, at any instant a narrow vertical slit-like area over the letter being "active." One cell responds to descenders, five to the main body ("x" height), and two to ascenders of the letters. These cells control the action of eight tactile stimulators arranged to vibrate under the finger tips of four fingers, two to a finger. These stimulators are solenoid driven.

Work reported by Linvill on piezoelectric bimorph stimulator motors, and the advantages of having more than a narrow one-column scanning aspect for a system, led Mauch personnel to examine the possibilities of producing a three-column Visotactor using an 8 x 3 array of cells and corresponding bimorph vibrators. Such a device was built mostly within the same size structur used for the Visotactor B, but for the prototype version a transformer and inverter circuit used to supply the bimorph operating voltage were mounted in the external battery plug rather than in the already well-filled space of the probe. A blind subject will try the device, first using one column, then two, then three. Some measure of the advantages or otherwise of multicolumn arrangements should be forthcoming from this work.

Mr. Smith closed by mentioning some general features of the Mauch Laboratories hand-held probes. The optical barrel can be rotated 15° to help with reading of italics. It also has a vertical movement allowance of about 1/8 inch relative to its running rollers to permit reading materials in the plane of the rollers or further away under a sheet of 1/8" glass as used in the Colineator. The Colineator, described in (26), is a tracking aid developed at Mauch Laboratories. It involves a glass base plate, precision ground rods connected with a roller equipped cross bearing, and an equalizing connector by which the probes are fastened to the device.

VI. VISUAL EFFECTS THROUGH STIMULATION OF REMAINING PARTS OF THE VISUAL SYSTEM

Professor Sterling then spoke briefly on some of the interests of the Committee on Professional Activities of the Blind of the Association for Computing Machinery. He pointed out that some years ago it became clear certain blind persons would be employed in the computer profession. To facilitate such employment, the Committee, of which Professor Sterling is chairman, developed means for high speed low cost production of braille readout to serve as a working tool of blind computer personnel (27). A light sensitive probe to "read" the consoles was also reinvented, perhaps "for the 28th time" (28).

The Committee continues to seek out those developments in technology and their applications which will aid the blind professional in computer work. It has also done some work on use of the computer to produce braille.

It seems almost natural that the thoughts of the "Young Turks" and "computerniks" of the Committee would turn to the question, "How can you get blind people to see?" A clever person at the time of World War I conceived the optophone transform -- different patterns of blackness producing different patterns of tones which a person could interpret. Today a person having similar acumen to his earlier counterpart would not think of an optophone, but rather of preprocessing logic circuitry to receive optical information and reduce it to electrical or other signals which could be used in a display a person could best interpret. Considerable attention has been given to auditory and tactile displays, but the Committee is intrigued by another more interesting possibility -- feeding the information directly into the brain. Recent developments in microcircuitry have brought within technological and economic feasibility the development of complex but compact devices for sensing and encoding environmental information. Given the possibility for linkage with the central nervous system, an instrumental substitute could perform some functions of the human eye. In the opinion of scientists who have given the problem careful evaluation, the various applications of technology to visual prostheses for the blind are primarily physiologic and psychologic. It is believed by some that attempts to bypass diseased peripheral structures and to produce artificial sensations for the blind and the deaf are virtually certain since simple forms of sensation may be obtained by electrical stimulation of the appropriate peripheral or central structures. Such observations as exist prove the feasibility and usefulness of artificial sensation; however it is by no means certain.

The group adjourned after the first day of sessions at about 5:00 P.M.

VII. INTERMEDIATE MACHINES

The morning session, January 23, 1966 commenced with remarks from Dr. Nye. He believes the ultimate goal is to go from print to something a blind person understands readily, like speech. The means to accomplish this are difficult and there is a place for a compromise intermediate system, one not quite as simple in concept as the direct-translation optophone, nor as complex and expensive as a character recognition unit with some sort of speech output.

Dr. Nye then told of some of the work on audible outputs he had been associated with at the National Physical Laboratory (NPL), Teddington, Middlesex, England (29). The work there was on behalf of St. Dunstan's, a British organization for those blinded on war service. The Parametric Artificial Talker (PAT), designed by Walter Lawrence, was used in an attempt to get at a synthesized speechlike sound display using low-information-content parameters derived from letter shape. The letters are first scanned by a Nipkow disc. The information as to location of "black" or "white" is digitized, and by a mask-matching type of comparison a feature extraction analysis of the digitized letters is made. Presence of six features is noted: ascenders, ribbon height verticals, curvature downward, curvature upward, horizontal continuity, and an on-off switching function derived from the horizontal continuity data. This information is stored in token matrices. After a "smoothing" process operating on the discrete binary elements of these matrices, six analog control signals containing letter information resulted. These six signals were used to control six parameters of PAT: Noise, formant 3, formant 2, formant 1, larynx frequency, and larynx amplitude.

Other output sounds were also tried using the NPL equipment. Variations of the optophone tones were tried under the heading of multidimensional optophone. Learning curves from the several experiments at NPL were similar to the curves obtained at Haskins Laboratories in 1945. Performance then with "Wuhzi" (a synthesized consonant-vowel-consonant type of speech-like utterance) was a little better than that in recent work with PAT, which in turn was better than that with the multidimensional optophone. All of these richer display systems seem better than the original optophone. Dr. Nye feels the richer displays should be explored. He does not think it necessary to wait for more theoretical knowledge of speech itself.

Dr. Cooper commented that the intermediate machine may prove to be worth pursuing, and that those who feel they need not wait for complete knowledge of speech production may be correct. He cautioned, however, that the semi-arbitrary sounds which could be expected as output from such intermediate machines may not "lock into" the speech system, and may fall far short of displaying the superior information transfer capabilities of speech itself. Dr. Cooper pointed out that the serially arranged strings of phonemes which comprise speech are only superficially like the strings of Morse code sounds, optophone sounds, or other serial encodings mentioned by Dr. Nye. Current evidence points to assimilation of speech through a process of decomposition, or decoding, of the phoneme string into parallel streams of information which the brain reassembles in deriving the linguistic units and so the meaning of the utterance. This parallel processing, perhaps operable only with the sounds and sound sequences of speech, probably accounts for the unique capabilities as an auditory signal possessed by speech alone.

Dr. Nye played the gramophone record containing samples of several outputs for reading machines for the blind (29). There were questions about the recordings and learning curves mentioned by Dr. Nye. Mr. Smith commented that the discriminations achieved were among a few words or letters, not complete fonts or large vocabularies. Mr. Mauch inquired about the possibility of identifying an unknown geometric shape using intermediate sound codes, and also what the effects of vertical misalignment would be on ability to use the codes successfully. Dr. Nye replied he did not know the answers to these questions, and that these things were some of the daunting features in the work. Professor Benham asked for clarification as to whether these codes were easier to learn than the ordinary optophone code. Dr. Nye said that for comparisons based on an eight word vocabulary a simulated speech-like output was superior to a multidimensional optophone which in turn was better than the ordinary optophone. The rate and accuracy were better for those displays having more dimensionality, or in other words, more discrimination features between the several words.

Mr. Smith said that feature extraction wherein risers, descenders, up and down curvatures, etc. are determined goes a long way toward a complete recognition process. He asked what the advantage was in stopping short of full recognition. Dr. Nye answered that the philosophy was to throw as much burden on the user as possible, to use the computer in his head rather than to strap one to his back. Just to present the visual patterns in serial form as is done in the optophone violates a number of rules dealing with the perception of information by auditory means. The limited processing done in intermediate systems is introduced to overcome these violations. The aim is a workable system simpler to use than the optophone, yet simpler in physical construction than a full-fledged recognition system.

VIII. OTHER SYSTEMS OF "READING" FOR THE BLIND

Mr. John K. Dupress spoke on computer conversion of ordinary language to braille. He said he would cover two possible input formats; punched cards produced by key-punch operators who need not know braille, and compositors' tapes from the publishing industry. To date only one full-scale facility exists for the automated production of Grade II Braille. This is at the American Printing House for the Blind in Louisville, Ky. (30). The system uses an IBM 709 computer donated by the company about three years ago. Over 100 books have been transcribed to Grade II Braille so far, and the resulting product is estimated to be better than 90% error-free. Statistical information regarding braille has also been compiled using the computer at Louisville. Mr. Dupress also referred to computer work on braille at MIT where Gerald F. Staack (31) found that Grade II Braille saved 25.6% in terms of cells used over Grade I when literary texts were checked. For scientific and technical materials the savings were down to 15%, 10% and sometimes less. Mr. Dupress said he mentions this by way of counterfoil for those people who feel that only perfect Grade II Braille warrants consideration for serious braille use.

There have been attempts to write braille programs for smaller computers than the 709, but Mr. Dupress said, to his knowledge, none so far has produced such perfect braille as the 709 system at Louisville. Abraham Nemeth has worked out a program for the 650 computer, a student at MIT working with Ted Glaser has written one for the PDP-8, and one is being written at USC for the Honeywell 400. These smaller machines generally leave out some contractions and have smaller dictionaries. Some braille experts are very adamant that one just should not violate any of the braille rules. Mr. Dupress feels this is a very correct position. He said that a sensible approach to using a smaller computer would be to settle for braille without errors of commission, but perhaps with some omission of contractions in certain rare words. A little more space would be taken by spelled-out braille in these instances, but probably not too much more.

Regarding conversion from compositors' tapes to braille Mr. Dupress said he was trying to complete work at the MIT Sensory Aids Evaluation and Development Center which was started by two students, Gammill (32) and Thornhill (33). At first it was thought the work of these students, "Teletypesetter" tape to input for a braille translation computer, and "Monotype" tape to braille translator input respectively would be completed at the Center. As the work progressed, however, it became evident a single more general and flexible system could be usefully developed at the Center vice the two systems first considered. This led to the DOTSYS design with capabilities to accept information in a variety of forms in addition to "Teletypesetter" and "Monotype" tapes. Various outputs will also be possible; punched cards to control braille stereograph machines, magnetic or punched tape, control signals for a high-speed braille embosser or a computer line printer adapted to produce embossed braille, or even eventually control signals for a speech generator. The DOTSYS arrangement will also include a way for human editing by a person who need not know much about the particulars either of the input tapes or the ultimate braille output.

Sometimes only an ephemeral form of braille is required, or at most a few copies of an embossed document. Mr. Dupress mentioned the IBM Braille Belt Reader (34) saying it required more engineering development, and the Blanco braille display developed at MIT by Professor Blanco. This is a simple device using three of the positions in each of two adjacent columns of Teletypesetter tape perforated in a "negative" braille code, i.e. where a dot is required no hole is punched, where no dot is needed the hole is punched. Rounded-end pins which drop or not into the holes in the tape are thus raised in braille cell patterns for sensing in more-or-less customary fashion with the finger tips. This unit is being run on reliability tests at SAE&DC, and if it stands up, plans call for a subsequent user evaluation study.

Another possibility for output is through use of an electrically operated braille embosser fed with punched card, tape, or other storage medium. Attempts to electrically power the Perkins Brailler have not been too successful. Attempts to develop a high speed embosser at MIT have led to what is considered a fairly reliable unit capable of operating at 16 cells per second. Mr. Dupress also mentioned braille-embossing adaptations of computer line printers at University of Cincinnati, MIT, and in industry. These have generally produced dots 8 or 9 mils in height as measured by SAE&DC. A British engineer in the Honeywell Co. has used steel balls from ball bearings as an embossing means in a line printer. His adaptation produces fine braille with dots 18 mils high at a rate of 430 lines per minute. It seems that school systems owning computer equipment should, in off hours, with the help of some special programmers, be able to produce braille, relieving the special education teacher of this task.

Professor Werner briefly reviewed the results of mechanized braille production in Germany saying their error rate was about the same as in the English systems described. The German habit of compounding words into single new words with lengths upwards of 30 letters not uncommon, leads to problems in machine separating at the ends of lines. To date only whole words are printed on a line. This has caused wastage of about 3% of the space devoted to the text.

Mr. Dupress spoke briefly on the low rate of errors found in braille released by braille-publishing organizations, feeling satisfied with their record and in agreement that they set, and should set, high standards of braille excellence. Other braille in the field, very necessary and useful too, produced by volunteers may be of lower quality.

Professor Werner said that when some machine-translated braille was sent around to several blind readers for checking, they characteristically produced different lists of errors for the same copy. This leads Professor Werner to feel the errors in the machine product are not too serious. He also told of a movement in Germany to modify slightly the rules for German braille to make it more amenable to production by machines.

IX. OUTPUT/DISPLAY SYSTEMS

Professor Metfessel indicated he would speak in terms of his general approach to the subject of spelled-speech, reserving details for his final summary report to VA due in the first half of 1967. Spelled-speech is an output system based on known material for all persons who know how to spell in the language concerned. The alphabet used in the tape-recorded examples played at this meeting was described as quite flexible, usable at speeds from 1 wpm to 120 wpm. Professor Metfessel said almost any spoken alphabet is satisfactory at speeds up to about 70 wpm, but above that problems are encountered.

With the Metfessel alphabet however, comprising 26 letter and 10 number sounds, any words or numbers can be generated at a wide range of speeds without being too offensive to the listener. Dr. Metfessel mentioned that he believes this "parametric" alphabet to be good up to 120 wpm, but that rates only up to 90 wpm will be demonstrated at the meeting. A general base in developing the alphabet was to preserve unity yet to have variety. The work involves some aesthetics here in deciding against pure monotone pronunciations. The feeling is that "neutral" alphabets, having homogeneity with variations, will turn out to be best. An imporant consideration is the need for "compatability" of all the sounds too. This is achieved by recording a whole alphabet by the same voice or the same tape through the same microphone using the same bias setting all at one recording session.

Before playing some illustrative samples Professor Metfessel called for greater standardization in methods of measuring and reporting speeds of utterance in audible output systems. While the unit used in reporting is usually words per minute (wpm), this can mean different things to different workers.

Professor Metfessel and Dr. Lovell then played some examples of spelled-speech at a rate of 15 wpm net including spaces between words to allow ample time for listeners to write down the words heard. Without including this time for writing the rate would be about 30 wpm. The text of illustrative sentence number one was, "These sample sentences present a special set of letter sounds one at a time." Beginners with spelled-speech start with material presented at this rate and achieve 96% correct responses when tested. Rates between 15 and 30 wpm are often the limits achieved with other systems after weeks or months of training.

The basis of the current Metfessel spelled-speech is equal interval presentation. There are four possibilities: 1. the end of each letter can mark the end of the interval, 2. one can center the letter in the interval, 3. one can use the start of the letter as coinciding with the start of the interval, or 4. one can position the letter randomly within the interval. The best results have been obtained when the start of the letter and start of the interval were made to coincide. A longer interval between words and between sentences helps.

The same sentence was then illustrated at 16 wpm net [still quite intelligible to your untrained editor of these notes] or 50.1 wpm neglecting the spaces between words left for writing [the spaces incidentally helping a pure listener too]. The same sentence was presented at 90 wpm with writing pauses between words and was still quite intelligible as was also a new sentence at the same speed, "You will hear some words at the rate of spelled speech later in this session."

To produce these sounds Professor Metfessel "cut down" the natural letter sounds in certain ways -- sometimes at both ends, others at only one end. In the rules to be published in the final report, one will find all the experience gleaned during the course of this project relating to how letters can best be "tailored" for purposes of time compression.

As a last example of spelled-speech sentences the professor played the same sentence number one plus some new ones at about 90 wpm but without extended pauses between words. He described this as the normal presentation mode for people who have some training and familiarity in the system. /These materials were less understandable to your editor, but much of the meaning got through./

An illustration of the means of getting the recordist to produce the letter sounds was then presented. A set of sentences followed by letter strings was used, and then desired letter sounds were isolated from the strings, e.g. "Let the boys bring the cheese in the PQRST." The "R" in PQRST could then be isolated on the tape and used as one of the alphabet set. Another related way used to get sounds was to have recordists spontaneously read sentences filling in missing ending words. Within these sentences were letter pronunciations which could be isolated and used. For example in the sentence, "Ten stories up was the (office). the "en" of Ten was used as an "n" sound, or in "Every girl on the beach deserved a (prize). "the "bea" of beach was the "b" sound.

Mr. Dupress inquired whether there was any material at 120 wpm which could be demonstrated. Professor Metfessel replied no, but said such a speed would be reached with compatible spelled-speech.

Mr. Rogers asked about the span of attention for spelled-speech vs. regular speech, and Professor Metfessel said he has only made a start at getting data which would enable him to give an answer.

Dr. Cooper said the principal emphasis of his work for VA was on audible outputs for high performance reading machines for the blind. High performance means at sufficient rates to satisfy users who wish to read extended texts of considerable lengths. Realizing there may be room for argument Dr. Cooper's underlying assumption was that to achieve high performance the machine would have to "talk English," i.e. have a fairly natural speech-like output rather than one of the coded ones.

Dr. Cooper had prepared some written notes and a set of slides for his talk in association with Miss Gaitenby, also of Haskins Laboratories. Much from these notes and slides has been included in what follows, edited and expanded on only to the extent thought necessary to put the materials into the format of this paper:

"What Miss Gaitenby and I shall have to say about audible outputs for reading machines will be, in part a general discussion of problems and possible solutions and, in part, a status report on the research underway at Haskins Laboratories. It may help if I start with an outline of the topics we propose to cover.

TOPICS

1. Reading Machine Research at Haskins: Aims
   (Sponsored by PSAS, Veterans Administration)

2. Varieties of Speech Outputs from Reading Machines.

3. Report on Haskins Reading Machine Research:
   - Past work on Synthesis-by-rule; Interim Word Reading Machine
   - Compiled Speech; Demonstrations

4. Feasibility of High-performance Reading Machines.
   - Relative Merits of Various Types
   - Time and Cost Factors
   - Major Problems

5. Current Work and Plans.

First, we shall say very briefly what we think the problem is, what the aims are of the research that Haskins Laboratories is doing for the Veterans Administration and where this work on reading machines fits into the Laboratories' overall speech program.

Next, it will be useful to distinguish among the various kinds of speech output that reading machines might generate, and get some names attached to generic types.

Third, we shall report on the status of research at the Laboratories, with some demonstration recordings.

Fourth, we shall take a general look at the prognosis for speech-type reading machines, considering the advantages and disadvantages of several types, and estimates of how much longer their development may require and about how much it may cost to operate them.

Finally, we shall say what we plan to do for the next several months.

Let me start, then, with the aims of the Haskins program on "Audible Outputs of Reading Machines for the Blind". The title is less specific than the actual research aims, in that it implies a search for the optimal compromise between the needs of the listener and the cost and complexity of the machine. There may well be a need for such research but, in fact, we are starting from the assumption that only spoken English will prove acceptable for a high-performance reading machine, and that the practical problem is, therefore, to find out how to generate acceptable speech in the best and simplest way. We think there are good reasons for insisting on speech as the output; we have discussed these reasons at length in various papers (35), (36), (37), and so will not repeat them here.

There are various ways to get a speech output, and I shall describe some of them in a few minutes. All require information about the identities of letters or words, which means that a complete reading machine requires optical character recognition as well as speech production. We have not included the OCR problem in our research, however, because we have supposed that that problem would be solved for the business community by the time we had a workable system for generating speech from letter information.

The aims of the Haskins program imply long-term basic research, though certain practical aspects are beginning to emerge. The work on reading machines is mainly on how best to produce acceptable speech from letter-by-letter or word-by-word information. Because this fits so closely into other work that Haskins is doing on speech perception and production -- and, indeed, depends so heavily on this other work -- it may be useful to indicate where the reading machine problem fits into our overall program." Slide 1 is a display of these several projects showing how they all serve, in one way or another, the reading machine project.

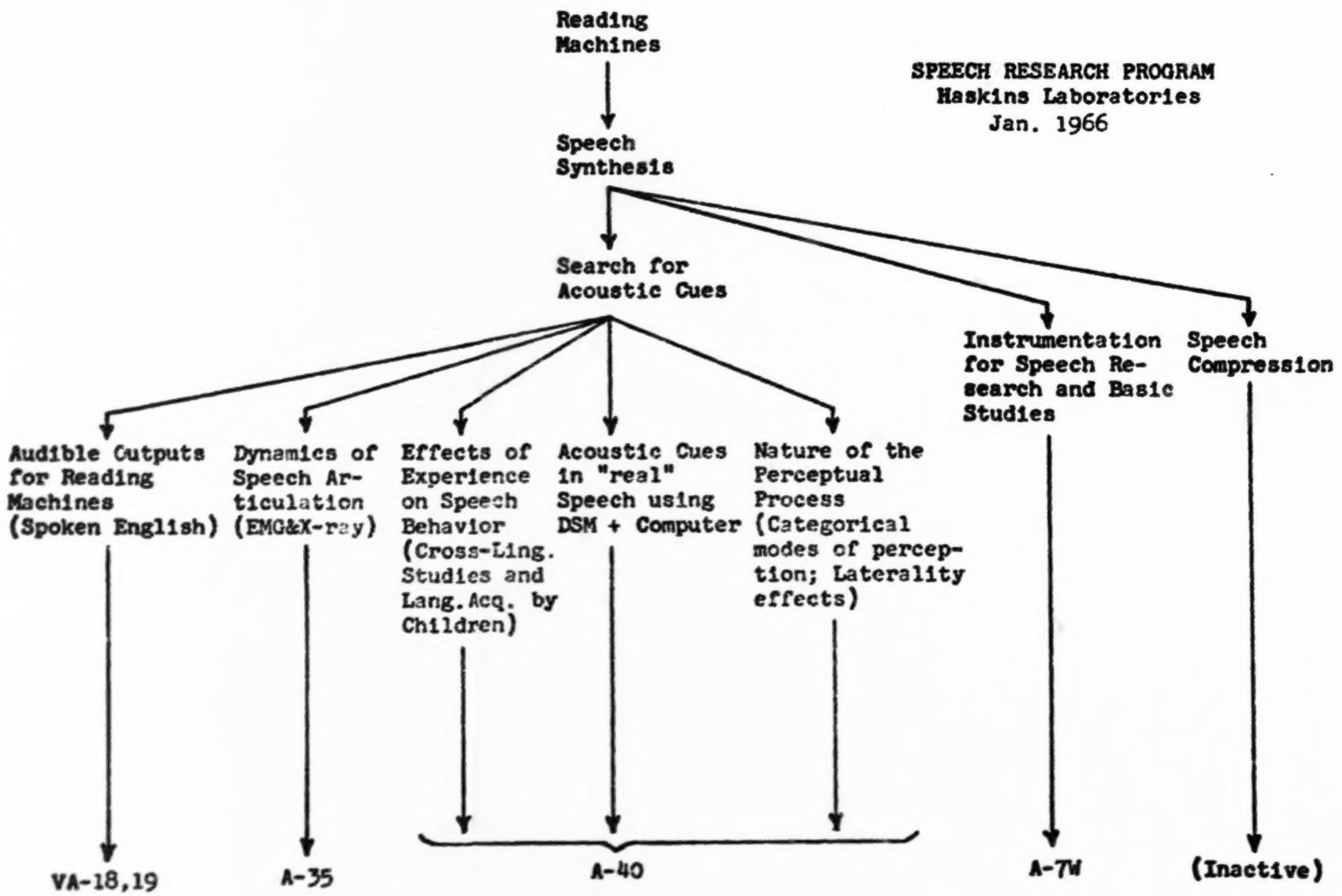
Dr. Cooper used Slide 2 to show how synthetic speech enters into the research at Haskins, and into the design of a reading machine system for the blind. Steps 1 to 3 carry the process from the letters on the printed page to the phonemes on which the synthetic speech is based. Steps 4-7 in the left column of Slide 2 show research steps already taken in the laboratory, those in the right column show what must be done to incorporate these ideas into a functioning output system.

Slide 3 shows a second type of speech output, compiled speech. Here one first assembles a dictionary of word recordings. Any new message is then produced by rearranging these pre-recorded words in the desired new order.

A third type of speech, re-formed speech is the subject of Slide 4. An advantage of this system over compiled speech is that there is opportunity to modify the stress and intonation of an utterance to improve naturalness. Less storage capacity is required to store control signals for a given number of words than to store the word pronunciations themselves as in compiled speech.

SPEECH RESEARCH PROGRAM

Haskins Laboratories
Jan. 1966



Reading Machines

Speech Synthesis

Search for Acoustic Cues

Instrumentation for Speech Research and Basic Studies

Speech Compression

Audible Outputs for Reading Machines (Spoken English)

Dynamics of Speech Articulation (EMG&X-ray)

Effects of Experience on Speech Behavior (Cross-Ling. Studies and Lang.Acq. by Children)

Acoustic Cues in "real" Speech using DSM + Computer

Nature of the Perceptual Process (Categorical modes of perception; Laterality effects)

VA-18,19

A-35

A-40

A-7W

(Inactive)

Slide 1

Synthetic Speech:

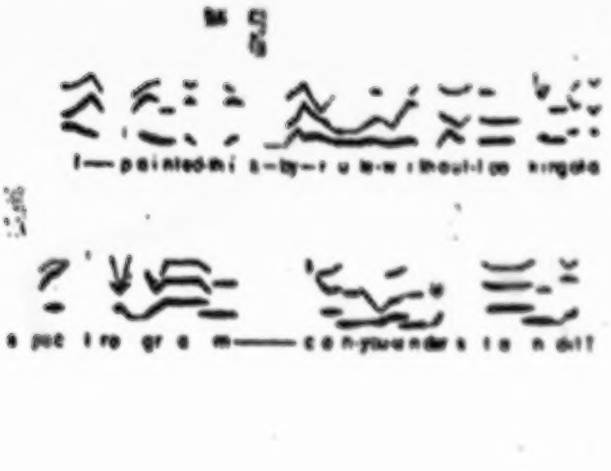
1) Printed Page
2) Optical Character Recognition
3) Spelling → Phonemes

HL Research

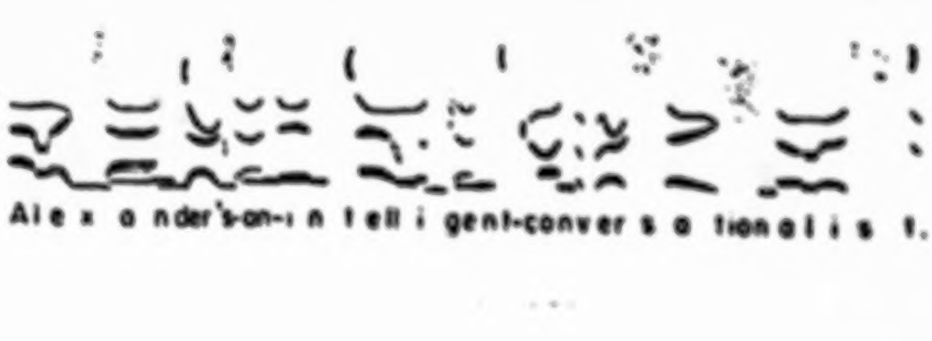
4) Apply Rules for Synthesis
   to get
5) Hand-drawn Spectrogram.
6) Use Pattern Playback
   to hear
7) Synthetic Speech.

Prospective Reading Machine

4) Apply Rules for Synthesis
   to get
5) Control Signals equivalent to a Spectrogram.
6) Use C.S. with a Formant-type Synthesizer
   to hear
7) Synthetic Speech.


I—painted thi s-by-r u le-w ithout-loo king at a
s pec tro gr a m——can-you unders ta n d it?

Rules for Synthesis


Ale x a nder's-an-i n tell i gent-conver s a tional is t.

Hand-drawn Spectrograms

Slide 2

Compiled Speech:

1) Printed Page + O C R

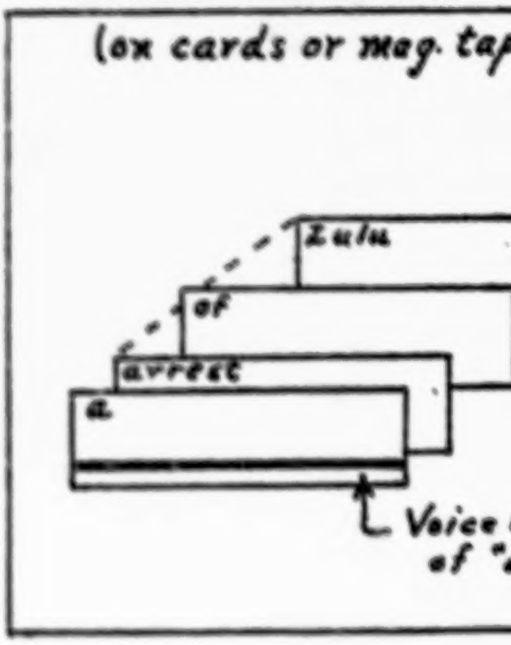
or

1) Teletypesetter Tapes

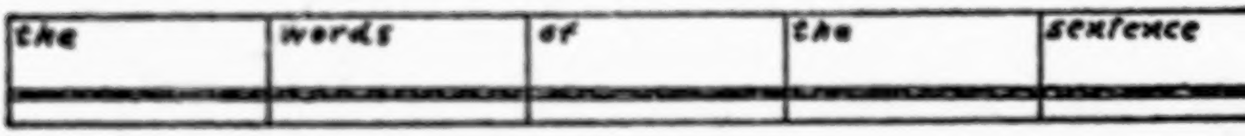
2) the words of the sentence

3) Use the spellings to find voice recordings of the words.

STORED VOCABULARY


(on cards or mag. ta
Zulu
of
arrest
a
Voice
of "

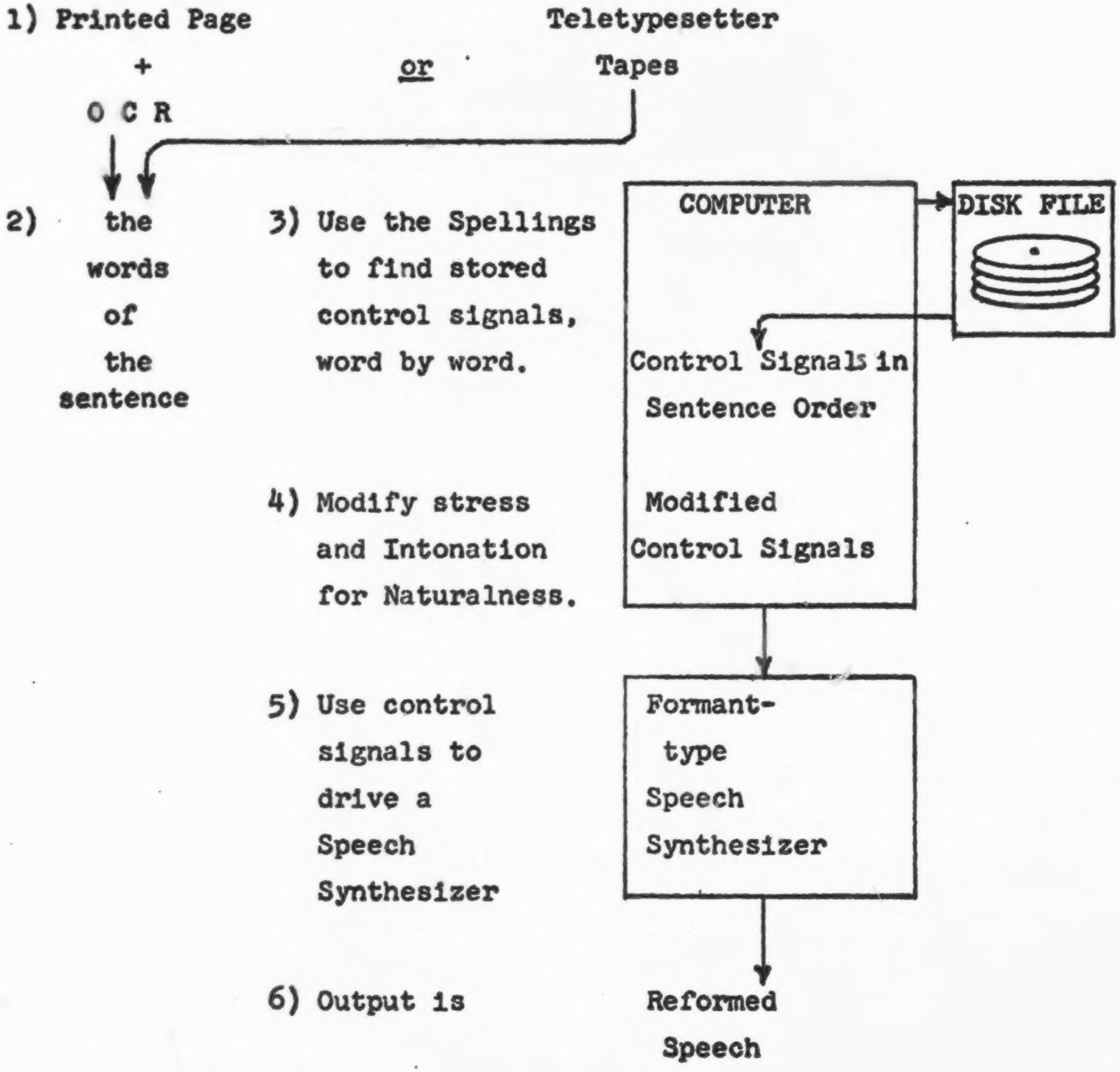
4) Rearrange cards to say


the
words
of
the
sentence

though not in the order in which they were spoken when the original recordings were made.

Note: The Interim Word Reading Machine performs the same operations, but uses a vocabulary stored on multi-track magnetic tape.

Re-formed Speech:



1) Printed Page + O C R *or* Teletypesetter Tapes

2) the words of the sentence

3) Use the Spellings to find stored control signals, word by word.

COMPUTER

DISK FILE

Control Signals in Sentence Order

4) Modify stress and Intonation for Naturalness.

Modified Control Signals

5) Use control signals to drive a Speech Synthesizer

Formant-type Speech Synthesizer

6) Output is

Reformed Speech

Dr. Cooper then went on to say he feels synthetic speech is the correct way to provide output for a reading machine for the blind. He referred to the work at Haskins wherein rules for synthesis have been developed, and where much attention has been given to studies of the acoustic cues for speech in various contexts, to intonation and stress in speech. He mentioned that an interim word reading machine had been built, but that advances in technology had pretty much made this device for machine splicing of pre-recorded word sounds obsolete.

Miss Jane Gaitenby conducted a demonstration of some materials produced in the compiled-speech system. She pointed out that words not in the 7100-word pre-recorded group are spelled out in the present recordings. Words that need spelling are precisely those which are long, unpredictable and often with odd spelling. They thus are not always readily grasped on first hearing. The first tape Miss Gaitenby played was a one-minute selection paced at 93 words per minute (with the overall average speed reduced by inclusion of some spelled words which take longer than pronounced words). The words "intentionally" and "unintentionally" were spelled out. Miss Gaitenby also noted that certain suffixes were stored in the vocabulary to increase its size. Included were the plural "s," the "s" for third person singular of verbs, the "ed" stored as voiceless "t," and a sound for the suffix "ted." The same selection was played again, but at a slower word rate. Miss Gaitenby told how the variations in pitch and loudness were mostly intentional, introduced by the recording speaker in response to instructions provided to him. The rationale for these instructions was based on linguistic knowledge of the probability that a given word would be used as a given part of speech, at a given point in a phrase, with a given stress and intonation. Slide 5 was used to illustrate some of this linguistic-probabilistic thinking. The larger the circles in the slide, the more the stress on that particular grammatical part of speech, in general. Also the weights of the directed segments between circles indicate the relative probabilities of occurrence in ordinary texts of sequential transitions between the parts of speech shown (33). Miss Gaitenby said that nouns tend to occur at the ends of phrases or sentences. Words coming before such pauses tend to be lengthened in time when spoken, and usually with a falling frequency and intensity pattern. The recording speaker for the compiled-speech dictionary was instructed to record nouns using such a pattern. Correspondingly, prepositions were recorded with low pitch and intensity as this is the way they usually occur in speech. Verbs present a problem because of their relative unpredictability as to stress and placement in a sentence. Slide 6 shows the intonational patterns the recording speaker was instructed to use. These data are based on linguistic observations as well as some acoustic measurements. Miss Gaitenby then referred briefly to a suggestion of Oliver Selfridge made at the 1962 International Congress on Technology and Blindness wherein he said he could not see why so much attention is given to inflection and intonation in reading machine outputs. No such information appears on the printed page! Miss Gaitenby said that while there are no notes on a printed page, independent readers all tend to supply strikingly similar reading patterns for a given text. She feels the pitch, intensity, and timing information is embodied in the words themselves and in a way is thus on the page.

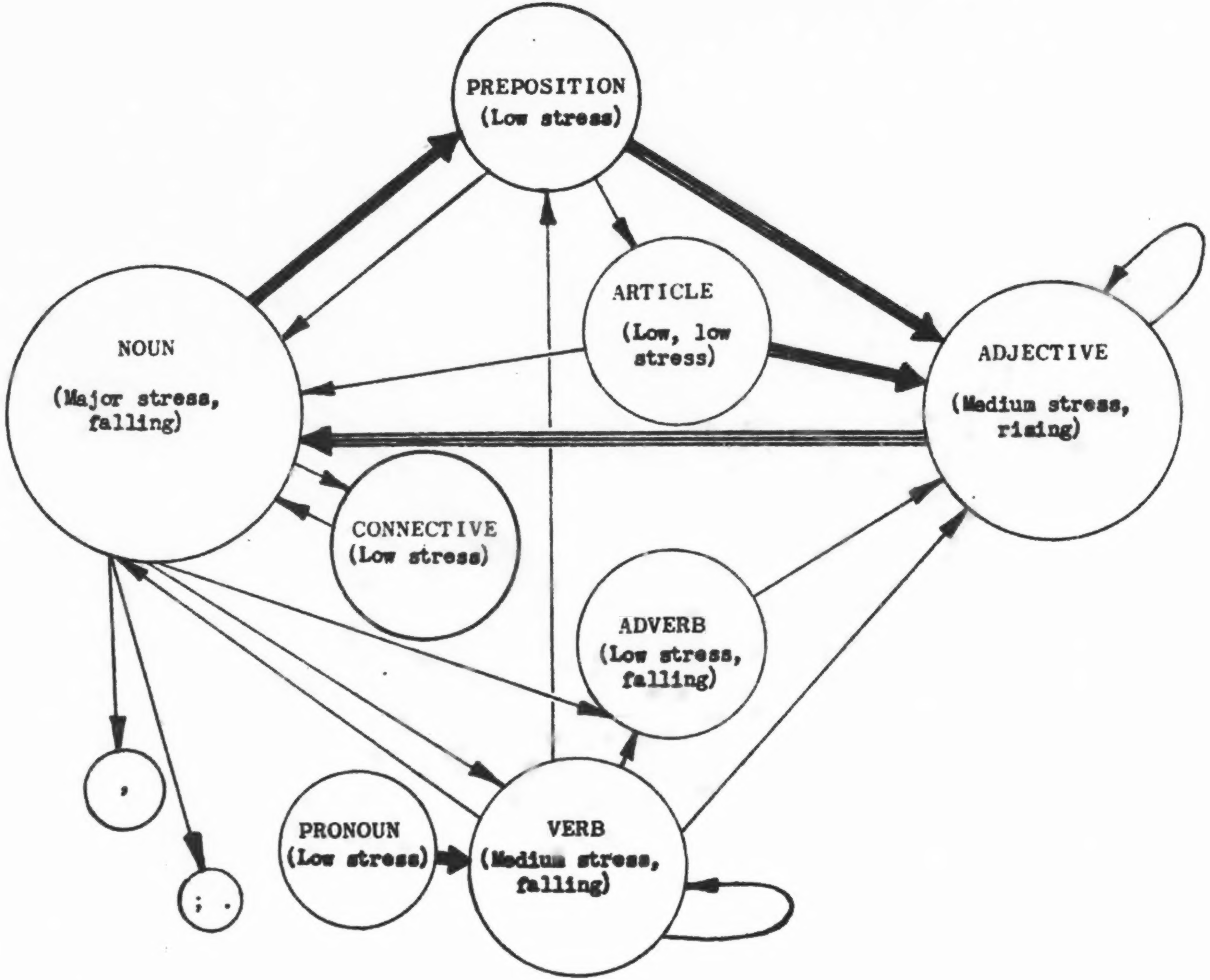
In the word reading machine only one pronunciation of a given word is stored. Bearing in mind the information in Slide 6, as a general rule a neutral delivery was sought for the one stored utterance per word. For texts not requiring any spelling it was found that passages could be speeded-up from the 102 wpm recording speed to 120 wpm (just by capstan change with accompanying pitch escalation) without loss in intelligibility. With spelled words included, a lower rate, in the order of 80-100 wpm was found to be better.

After a brief description of the word reading machine built at Haskins, Miss Gaitenby played a tape sample of its output at 80 wpm. A last tape, slowed to a net rate of about 81 wpm due to a fair amount of spelling, was then played. This tape included brief 400 Hz "beeps" just before and after spelled portions to alert the listener to the format next to be expected.

After Miss Gaitenby's demonstrations Dr. Cooper resumed his talk going into the possible varieties of reading machines which would produce the three types of audible output being considered at Haskins: synthetic speech, compiled speech, and re-formed speech. Slide 7 contains the bulk of the information presented by Dr. Cooper. At the left side of the slide are listed the several speech producing systems. At the right side are the types of speech produced, and in-between are the steps necessary to go from letter-by-letter information from an OCR (optical character recognizer) to speechlike outputs of the several kinds shown.

Dr. Cooper made some estimates as to quality of speech and speed of operation of the several speech-producing systems. These data, rough "horseback guesses," are tabulated in Slide 8. Similarly rough guesses as to the operating costs of the several systems are tabulated in Slide 9. Dr. Cooper said the general conclusion from these quality, time, and cost data, is that the phrase reading methods are best for reading machine outputs. They give good quality, use only medium sized computer facilities, and have estimated operating costs only one to two times those for human readers.

In conclusion Dr. Cooper predicted that within a few years the technical problems will be fairly well solved and the problem areas will shift to the organizational. Whether or not these high-speed, high-capacity systems will be used will be controlled by whether or not there are organizations functioning to make such use practical and efficient.

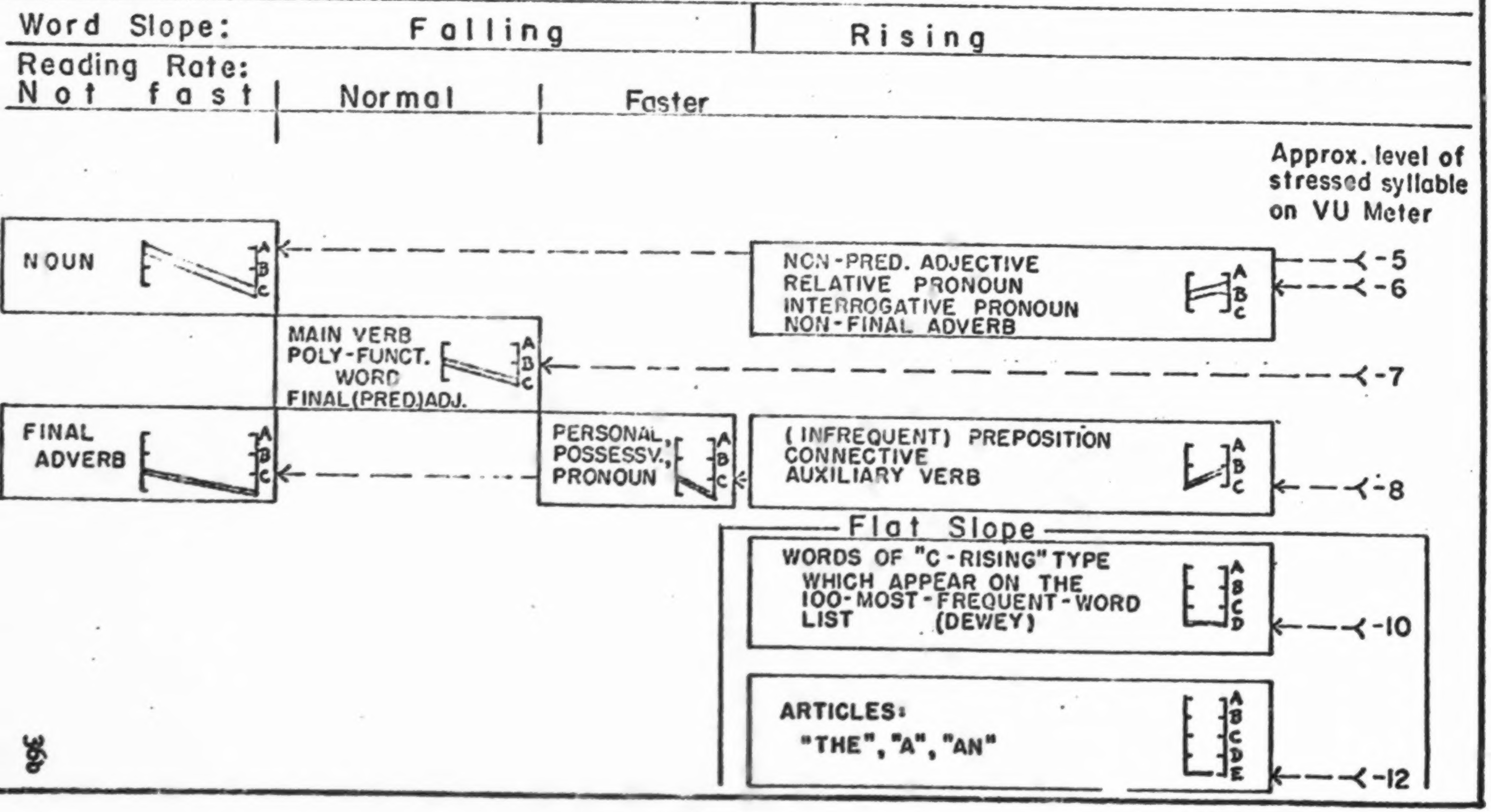

PREPOSITION
(Low stress)
ARTICLE
(Low, low stress)
NOUN
(Major stress, falling)
ADJECTIVE
(Medium stress, rising)
CONNECTIVE
(Low stress)
ADVERB
(Low stress, falling)
PRONOUN
(Low stress)
VERB
(Medium stress, falling)
,
; .

Slide 5

INTENDED INTONATIONAL PATTERNS FOR STORED WORDS

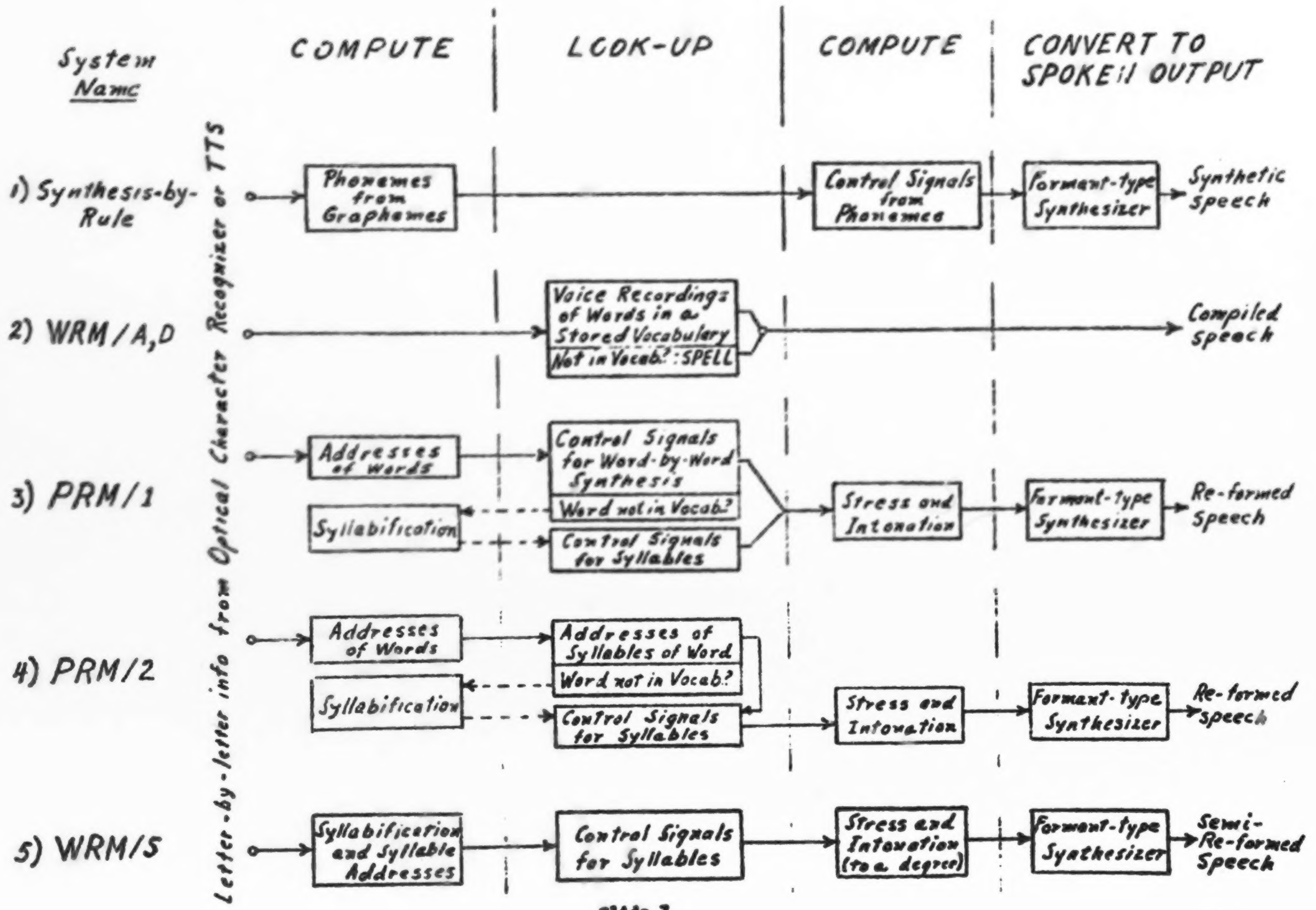
Legend:

	Pitch		Intensity
A	= Slightly above normal	→	ca. −5 on VU Meter
B	= Normal	→	" −7 " " "
C	= Below normal	→	" −8 " " "
D	= Far below normal	→	" −10 " " "



Word Slope:
Falling
Rising
Reading Rate:
Not fast
Normal
Faster
Approx. level of stressed syllable on VU Meter
NOUN
A
B
C
NON-PRED. ADJECTIVE
RELATIVE PRONOUN
INTERROGATIVE PRONOUN
NON-FINAL ADVERB
-5
-6
MAIN VERB
POLY-FUNCT. WORD
FINAL(PRED)ADJ.
-7
FINAL ADVERB
PERSONAL, POSSESSV., PRONOUN
(INFREQUENT) PREPOSITION
CONNECTIVE
AUXILIARY VERB
-8
Flat Slope
WORDS OF "C-RISING" TYPE WHICH APPEAR ON THE 100-MOST-FREQUENT-WORD LIST (DEWEY)
D
-10
ARTICLES:
"THE", "A", "AN"
E
-12

Slide 6


System Name
COMPUTE
LOOK-UP
COMPUTE
CONVERT TO SPOKEN OUTPUT
Letter-by-letter info from Optical Character Recognizer or TTS
1) Synthesis-by-Rule
Phonemes from Graphemes
Control Signals from Phonemes
Formant-type Synthesizer
Synthetic Speech
2) WRM/A,D
Voice Recordings of Words in a Stored Vocabulary
Not in Vocab?: SPELL
Compiled Speech
3) PRM/1
Addresses of Words
Syllabification
Control Signals for Word-by-Word Synthesis
Word not in Vocab?
Control Signals for Syllables
Stress and Intonation
Formant-type Synthesizer
Re-formed Speech
4) PRM/2
Addresses of Words
Syllabification
Addresses of Syllables of Word
Word not in Vocab?
Control Signals for Syllables
Stress and Intonation
Formant-type Synthesizer
Re-formed Speech
5) WRM/S
Syllabification and Syllable Addresses
Control Signals for Syllables
Stress and Intonation (to a degree)
Formant-type Synthesizer
Semi-Re-formed Speech

Slide 7

Estimates of Quality and Speed

SYSTEM	SPEECH QUALITY*	SPEED FACTOR	EQUIPMENT
1) Synthesis-by-Rule	3-4**	20xRT	Large computer(?)
2) WRM/A	5**	1/30	Experimental Basis with Interim WRM
WRM/D	5**	1/4	Experimental Basis with Computer
3) PRM/1	10	1 to 4	Medium to small computer with disk files
4) PRM/2	8	30 to 300	Large computer with ca. 100 K core memory
5) WRM/S	5	300	Medium size computer with 32 K core memory

* Estimates of relative quality on 1 to 10 scale
** Speech needs to be fairly deliberate for good intelligibility

Slide 8

Estimates of Operating Costs

SYSTEM	COST OF SYNTHESIS*	OVERALL COSTS**	COMMENTS
1) Synthesis-by-Rule	$6/hr	$11/hr	Special hardware could cut costs of synthesis
2) WRM/A	(high)	(high)	Cost high if computer used for control, or to build control circuits
WRM/D	$160	$165	Experimental basis with small computer
3) PRM/1	$10 to 40	$15 to 45	Depends on system size
4) PRM/2	$ 2 to 10	$ 7 to 15	Depends on system size
5) WRM/S	$ 1 to 2	$ 6 to 7	Depends on system size

* Costs are per hour of output speech on user's tape.
** Costs = (synthesis) + OCR @ $2/hr + labor & materials @ $3/hr.

Slide 9

Professor Benham next introduced Mr. David Shepard of Cognitronics, Inc. Mr. Shepard said his company has been selling speech composition equipment for some time, and that it is in use in a considerable number of applications. There are two series of "Speechmakers™" on the market, the 630 series including a digits-only model and a 31-word model, the 670 series ranging from 31 to 139 word models. All "Speechmakers™" consist of rotating cylinders carrying a plurality of photographic sound tracks, each track modulating the light directed to a separate photocell (39). Messages can be composed by selecting the output from words recorded on the tracks. The selection can be under control of a computer, a tape, an optical character recognizer or similar selecting means. The current prices range from under $1000 to several thousands for these models.

Mr. Shepard pointed out that Cognitronics has also been engaged in speech synthesis work for some time. Their approach has been to create intelligible speech based on the sounds of the phonetic symbols next to words in an ordinary dictionary. People with a few hours exposure to speech produced by Cognitronics in this way usually can understand a new sentence produced the same way. Mr. Shepard enlisted the assistance of the group by asking them to write down what they hear later in the program when Cognitronics-synthesized speech being produced in the plant at Briarcliff Manor, N.Y. will be presented to the meeting via a telephone hook-up. Mr. Shepard emphasized that this speech is computer synthesized from stored elements which are the sounds of a dictionary's phonetic symbols. His firm can also do re-formed speech. He said Cognitronics is hardware oriented and could benefit from the linguistic knowledge of Haskins Laboratories. He feels that the only problems remaining with speech synthesized from phonetic elements are in the "software" areas. A table lookup to enable the computer to convert from letter-spelling to phonetic-symbol will be required to get an optical character-recognizing front-end to "speak" words. On the basis of a series of tests conducted at Cognitronics, Mr. Shepard said that speech can for the most part be put together by stringing syllables one after the other. There are a few minor exceptions, for example with r, and l which often run into adjoining syllables.

Professor Benham asked Mr. Shepard for clarification as to details of the Cognitronics speech synthesis method, and Mr. Shepard reiterated they punched the message in a tape using the phonetic symbols and accent marks found in an ordinary dictionary instead of the letter-spelling. This tape then controlled the automatic release from the computer of strings of sounds taken from storage and assembled into the words of the message. Mr. Shepard then conducted a demonstration of the output of his synthesizer by receiving via the telephone line from Briarcliff Manor the following sentence repeated several times: "This is a speech synthesis machine." Messrs. Dupress and Lauer both said they got the message correctly after the second playing, others in the audience taking much longer.

There were then further questions on the details of Cognitronics' synthesis process. Mr. Shepard said that the stored phonemes were changed before utterance depending on accent marks, location in sentence, and proximity to punctuation. [This is somewhat analogous to the digital spectrum manipulator's action in Dr. Cooper's synthesizer at Haskins.]

Mr. Dupress then remarked he thinks it idle to consider only one solution to the reading problems of the blind. A variety of systems have their place, and some may become more important as the publishing industry becomes more automated and as volunteer personnel skilled in the computer arts turn some of their efforts to alleviate reading problems of the blind.

Professor Metfessel inquired of Mr. Shepard whether he can put together any words at all from his phoneme store. The reply was yes, but some doubt was expressed that the sound would be understood. Mr. Shepard feels improvements in the software, [i.e. linguistics and phonology of the situation] would lead to improvement.

Dr. White made a plea for considering the problem of sustained reading by a blind person for recreational purposes. He pointed out that upper limits of speed for systems mentioned so far seem around 100 wpm whereas ordinary speech speeded up by a factor of 4 in the "Tempo Regulator" (40), (41) is almost immediately intelligible. The ear can take in very rapid speech, and to be significantly better than Talking Book these outputs too will have to be usable at high speeds. [The editor wishes to note that not all reading is for recreation, and that for some tasks slow speeds on the order of 10-40 wpm may very well be useful. Speeds in this range using optophones have been achieved by Miss Jameson, Mr. Lauer, and a few others who all report positively on the values of independent reading even at such low speeds.]

Mr. Alfred Korb of the Division for the Blind and Physically Handicapped of the Library of Congress [since retired from that position] made some remarks on speech compression. He first made a distinction between "rapid speech" which is speech speeded-up by increasing turntable or tape speeds with associated pitch rise (monkey chatter or Donald Duck sounding in the extreme), and "compressed speech" which is time-contracted but without the pitch change. He also spoke of "fast speech" which is produced by a speaker speeding along like Walter Winchell at speeds of about 200 wpm. The trained readers producing recordings for the blind usually go at 150 to 175 wpm. Some braille readers read at 90 wpm while the usual 12th grader reads silently at about 250 wpm. The aim thus is to speed up the 150-175 wpm "Talking Book" recordings to at least the 250 wpm reading rate of the high school senior. Mr. Korb then referred to the early work of the late Dr. Anton Springer in Germany who obtained patents on an acoustical pitch and tempo regulator in the early 1950's, and to Prof. Grant Fairbanks (42) who published on a compression-expansion method in 1954. Mr. Korb then referred to a return post card survey the Library of Congress made on the desires of their listed "Talking Book" readers regarding compression. Mr. Korb did not indicate that any clear conclusion could be drawn from this survey. The Library of Congress has 30,000 people in its "Talking Book" program, perhaps from 6 to 106 years of age, and at all levels of intellectual attainment. The Library considers it should use only that degree of compression, perhaps 15% or maybe even 30%, which will produce recordings requiring no special training for use. High compression rates used by some experimenters could not be used in General Library work because the average home reader would reject such materials.

Mr. Alan Beaumont of the Solocast Company gave a brief talk on his portable phonograph, the "Solocaster," designed with the special requirements of blind users in mind. The unit is transistorized, operates from a rechargeable nickel-cadmium battery, is portable [3" x 3" x 9", weight 4 lb.], can be played while walking, riding, and with the case in any orientation, providing 60 minutes of playing time from the 7", 16 2/3 rpm records used. A special machine built in cooperation with Recording for the Blind, N.Y., N.Y. 10022 has adjustable turntable speeds from 14-35 rpm. This enables users to achieve some of the time-saving benefits of rapid speech. A test program with VRA assistance [VRA Project #RD-1903-S] involving 200 of the variable-speed machines gives promise that the idea is a good one. [In a later report dated September 1966, Mr. Jasha Levi, Project Director at Recording for the Blind, indicated that "The proposed functions of the machine - variable speed, forward and reverse scanning, instant start and stop, mobility of the unit - are ideally suited to the needs of the blind." The machines will require improvement if they are to provide reliably these desirable functions.]

X. RECOGNITION MACHINES

Mr. Mauch was first speaker at this session held the afternoon of the second day of the meeting, January 23, 1966. He pointed out the many differences between recognition machines built for commercial purposes, and those designed for use by the blind. The commercial machines are expensive, some costing $175,000 or more. They are also heavy, fairly large, and often operate only with "cooperative" type fonts especially designed to simplify the proplems of machine recognition. Multifont readers are even more expensive, heavier, and larger. Commercial machines usually have outputs designed to feed other machines such as printers, computers, or tape systems. These machines are also very fast. To justify the high cost they must be fast enough to replace perhaps 10-15 persons.

Quite on the contrary, machines for the blind must be relatively slow to allow for comprehension of the material being read and to enable the designer to meet certain cost, size, and weight limitations set by the practicalities of this application. The cost of a personal recognition reading machine for the blind should certainly not exceed that of an automobile, [and should preferably be less]. The unit should be portable like phonographs or tape recorders. It should be able to "read" some 9-12 fonts, perhaps three each of the most common ones used in newspapers, for typewriters, and in books or magazines. If nine fonts can be successfully "read," the chances are others will be "read" too but with less reliability. The audible output of the Mauch personal recognition machine is comprised of "words" formed from the sounds of Professor Metfessel's spelled-speech alphabet. The close presence of the human user of a personal reading machine throughout the reading process enables the designer to assign many functions to this user. The user must find the text on the page, set it right side up, align it to the guided scanner, note ends of lines, be able to change lines, keep on the line, scan, stop, repeat, change speed, establish degree of magnification necessary for proper operation of the recognition system, note whether regular type or italics, etc. It is the capability of the user to perform these manifold tasks that makes possible the design of a personal recognition machine.

While there are only 26 letters in the English alphabet there are many more characters in a font. A machine to recognize all alphanumeric characters in a font as well as special signs and symbols and foreign marks again becomes too complex to meet the stringent cost, size, and weight requirements of a personal machine. A compromise must be accepted between machine capability and complexity. The current machine at Mauch Laboratories has room for 31 different output sounds. These will be for the 26 letters (capital and small letters are separately recognized, but control the same spelled-speech sound letter-by-letter) and five printing ligatures, fi, ffi, ff, fl, and ffl. Note that numerals are not included in the automatic recognition capability of this unit. Numerals are quite important, often can't be determined by context, and must be reliably read. To allow for the blind person's reading of numerals, finding and orienting the text, setting the proper magnification level, etc., something more is needed. The unit of the Mauch Laboratories' system supplying this need is the "Visotactor A." This optical probe which fits the hand and is used with the "Colineator" contains a linear array of eight photocells as well as a selectively positioned set of 12 additional cells, all 20 cells occupying no more area than a dime. The eight cells in line respectively control eight fingertip-stimulators, two each under four fingertips of the user's hand. When the images of dark portions of indicia on the page pass over photocells of the linear array, corresponding fingertip stimulators are set into vibration. A form of tangible replica of the ink print on the page is thus fed to the blind user. It is by this tactile facsimile method that the user of the Mauch device will "read" numerals, marks, and signs not accommodated by the 12-cell recognition array and associated circuitry. The orientation, alignment, and magnification-setting tasks are also accomplished this way. Using the recognition machine, the blind person will always have his fingers in the "Visotactor A" finger rests. He will thus always have a tactile signal both along with, and during the absence of automatic recognition action. For many letters and words he will have a dual input system, tactile and auditory, a favorable combination which should improve speed and accuracy of reading. The whole system was successfully operated in the laboratory in November 1964. Less than 100% recognition accuracy was achieved, but considering the redundancy of ordinary English text, and the powers of correcting by context, the mistakes were tolerable.

Mr. Smith then gave some detailed information on developments at Mauch Laboratories (43). He indicated first that the developments to date have been of prototypes, and that it will be several years before any of the units will be available for general purchase. Outlining his talk, he said he would cover the "multiple snapshot" recognition technique, the bench-model laboratory-prototype recognition machine now completed, and the uniqu way in which the Mauch word synthesizer provides an audible output based on the Metfessel alphabet of spelled-speech sounds. Mr. Smith then presented a series of slides. The first slide was of the twelve-cell photosensitive array showing how information from the image of a letter "d" is sensed and sent to the temporary memory circuits. Mr. Smith mentioned the rectangular slabs of photosensitive material and the edges along which their electrical connections were made. He showed how a thin shadow line cutting across a cell somewhere between the electrode edges caused a much greater rise in resistance than the same thin line occurring on the cell so as to leave illuminated conducting paths between electrodes. He also referred to the "snapshot" technique wherein one of the 12 cells designated the trigger cell operated on each passage from white to black, or black to white, to cause the recording of the states of illumination of selected cells in the array, this information being routed to temporary memory circuits from which the aggregate information from the several snapshots is later decoded in a diode matrix to effect letter identification. Note that the states of all cells in the array are not stored for each snapshot. Depending on the snapshot sequence number as the trigger cell alternates between white and black as the letter passes, the states of cells of interest are recor in the memory, while those found not necessary by prior studies of the font are not recorded.

2 OF 2

ED

019181

1.0
4.5
5.0
5.6
6.3
7.1
8.0
9.0
10
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963

The second slide showed a block diagram of the recognition prototype. The "Visotactor A" forms the hand-moved optical probe section containing the photocell arrays. The cell state information is quantized into one of two states, "black" or "white." When four particular cells see "white" simultaneously this is an indication of "end of letter." The machine then decodes the stored information thus identifying the letter, recodes the letter information into five-unit Teletype code and sends the signal to the word synthesizer where the letter's sound is generated. After appropriate short time delays all circuits are cleared and reset for the next letter.

In the third slide Mr. Smith showed the optical bench setup for testing the cell array. The first array was designed entirely on paper bearing in mind the general shapes of letters in the fonts to be recognized. Then letters and ligatures of the nine fonts to be recognized were photographed from type style books, the letters were sorted, and slides made bearing, for example, all the g's of the set. The slides were projected on an enlarged representation of the photocell array and the operator noted and recorded the cell states in a punched-card system. A study of the cards was then made to determine whether recognition would be feasible for the cells used in the snapshot system. Necessary adjustments in unit photocell sizes and locations were made to insure unique recognition. On completion of this projector-paper screen process where the array was just drawn on the screen (five times larger than the final array), a five-times larger actual cell array was constructed to test the actual circuit action as the many letter samples were projected onto the array. A small "flooding" lamp was used to degrade the contrast at the test array of the fine slide images to approximate levels which would come from actual print images.

The fourth slide showed the miniature array used in the "Visotactor A." Mauch Laboratories had to develop the process for making this small, complicated array because commercial manufacturers were not interested in such a low quantity, highly difficult, development job. Special photo-etched masks were made, through the openings of which indium was deposited in a vacuum process onto slabs coated with cadmium selenide. The indium provided the conducting electrodes, the CdSe the photosensitive material. The necessary insulating areas were then produced with the aid of another mask and an "Airbrasive" unit which was used to remove CdSe as necessary to produce the required pattern of insulation. The array was then encapsulated with epoxy under a glass cover plate with silica gel included as dessicant.

The fifth slide showed the recognition machine prototype, a unit featuring so prominently an indicator-lamp array, useless to a blind person, but very helpful to laboratory personnel working on the development of the unit. The input connection to receive the lead from the "Visotactor A" was visible. A bank of 12 of 13 lights shows the states of the Schmitt trigger circuits responsive to the light or dark states of the 12 recognition-array cells. A group of 27 of 36 installed lights is used to display the states of the memory units, and a bank of "output" lights indicates continuously the letter

N

identification being made by the machine as its process unfolds. For example when a "d" is being scanned from left to right the machine will first "see" a "c" and so indicate by showing an illuminated lamp at the c" location. When the whole "d" is seen, the "c" lamp will go out and the "d" will come on.

Mr. Smith's sixth slide showed a plot of recognition accuracy versus vertical misalignment of the probe relative to the line of print. The data for this slide were obtained by mounting the Visotactor probe on a micrometer-feed stage to operate in cooperation with printed type on a rotating drum whose speed could be varied to achieve different reading rates. From center position where all 26 letters were correctly recognized the probe was shifted above and below in steps of 2.5% of the height of a lower case "x." The curve showed the device quite usable when misalignment was up to 10% of the "x" height. Plans are already made for a Mark II device which should be more tolerant of misalignment, and which will operate at higher speeds. The seventh slide showed the laboratory apparatus described above including the type drum and micrometer stage.

Slide eight showed the "Word Synthesizer" (44), the oldest of all the component parts of the Mauch recognition machine. Mr. Smith then explained the operation of this electromechanical device comprising 160 stainless steel spring arms carrying tape recordings of spelled speech sounds at their "flag" ends. There are five replications of each sound to allow for multiple use of the same sound in a given word. The arms are constantly urged to rotate by virtue of their slip-clutch mounting on a central rotating shaft, but only selected arms released by an unlatching mechanism actually move from their storage locations to a line-up position where the elementary spelled-speech sounds (on tapes on the "flags") are assembled into sequences (words). The "word" then passes the playback head and is reproduced in the speaker as a compact spelled-speech word. A tape recording of the word synthesizer producing "The quick brown fox jumps over the lazy dog" in spelled speech was then played. This sentence involves 44 letters and spaces and takes nine and a half seconds time /about 56 five-letter-space wpm, but because the inter-word spaces are longer than the individual letter spaces the intra-word speed is higher than 56 wpm./

The remaining three slides shown included one of the word synthesizer, one of the locally designed perforated tape reader which allows control of the word synthesizer by a punched tape, and one of the special re-recording device comprising a turntable to permit magnetic tapes to be played back when flat-mounted on the face of the vertical rim for concurrent re-recording in an arc on tape fixed to the flat surface of the disc.

Speaking of future plans Mr. Smith said the existing prototype will be kept in the laboratory and a Mark II designed with new photocell array and matrix. Rather than trying to give each letter equal emphasis in terms of recognition capability of the device, rare letters like the capital "Q" will be given less attention with concurrent improvement in ability with other letters. Mr. Smith said he had no information on the influence of errors on perception of spelled speech, whether common letters or the uncommon ones, in particular instances, carry the most significant cues for perception. The present unit operates at 85% to 90% accuracy on the nine selected fonts. If prevalence of lower case letters is included as a weighting factor the accuracy is higher. The Mark II unit will be designed to allow greater tolerance for vertical mistracking. Unimpaired operation with up to 10% vertical mistracking is the goal for the new unit.

A brief discussion then ensued between Mr. Hathaway and Mr. Smith on the relative values and complexities of a machine with phonemic versus spelled speech output. Mr. Smith indicated the machine could not be as small or as simple if the grapheme to phoneme translation were also built in.

Dr. White inquired about the possibilities of using masks to adjust the photocell array geometry for additional new fonts. Mr. Smith said this had been considered for an earlier single snapshot machine where a fiber-optics insert over the array was to be used to change its geometry slightly. /Not used in the current nine-font device, it seems evident that if additional fonts could be transformed to similitude with the nine design" fonts, they too could be recognized with about the same accuracy./

Professor Werner said it looked as though composing audible words from knowledge of their constituent letters is easier in German than in English. He asked if anyone produces a machine he could load with German sounds and key with tapes on a computer. There were several suggestions from those present. The unavailable single model of the Mauch word synthesizer was mentioned along with Cognitronics "Speechmaker" units, and for less automatic operation, the Language Master card system and just plain tape snipping and reassembly.

A section of the meeting dealing with contributions from firms currently working in pattern and character recognition was scheduled for this point in the sessions. Few who said they would come actually arrived, this probably a loss to be ascribed to the unusually severe weather conditions. Mr. David Shepard, one such representative of industry present, agreed to brief the group. He said machines exist at the present time which do a good character recognition job. A machine developed by Philco Corporation can read thousands of characters per second of upper and lower case typewritten material, perhaps from 50 different fonts comprising about 90% of all typed material. These pages are read by the machine even if produced under ordinary conditions in the field - special high-grade "laboratory" typing is not required. Obviously unable to do pricing for Philco, Mr. Shepard said he thinks the machine costs about half a million dollars. He has heard of somewhat similar equipment produced by Recognition Equipment Company of Dallas, though he has not seen this personally. He then mentioned the firm he started years ago, Intelligent Machines Research, which sold machines in 1956, some of which are still in operational use. This company was purchased by Farrington in 1959, and according to a company brochure they now have about 75% of all OCR (optical character recognition) equipment in existence to their credit. They have worked mostly with single-font applications, sometimes with specialized characters. Mr. Shepard said these restrictions were for business reasons alone, and not due to any technical difficulties. Some multi-font ordinary-character machines have been produced by this manufacturer too.

Mr. Shepard then turned to the many real problems that exist in applying commercial OCR techniques to reading for the blind. Looming large are problems of dealing with varying formats, two columns versus single column presentation, headings, pictures, advertisements, etc. Mr. Shepard says he knows of no manufacturer claiming his equipment will read material not prepared in some way "cooperatively," with the thought in mind it is to be read later by machine. No machine known to Mr. Shepard will do well on assorted material just picked up from a desk and fed to the machine. Emphasis in commercial designs has been on speed, accuracy, and volume, characteristics related to making the expensive machines economically feasible. In response to a question from Mr. Mauch about other companies in the field, Mr. Shepard mentioned the International Business Machines Corporation," with eighty percent of the market," the National Cash Register Company using a special font of their own creation, and Radio Corporation of America which had done a lot of work in the field, though Mr. Shepard does not know if their equipment is in use. He said the Rabinow Division of Control Data Corporation is also very important having announced a page reader at about $90,000.

Dr. Nye inquired about the term "cooperative" as employed in character recognition work. Mr. Shepard said it had to do with prearrangement of the details of format and type styles of the printing or typing. Sometimes it includes requirements on how often typewriter ribbons must be changed, and the frequency of maintenance checks on typewriters. The question of overlapping characters as produced in some typewriters came up, but Mr. Shepard mentioned that some machines can read text where adjacent letters touch, for example one of the Philco machines, but such machines are necessarily more complex than those which must deal only with letters separated by a space. The worse the paper quality, the worse the recognition problems was another remark of Mr. Shepard's. Mr. Dupress wondered about reading the New York Times with OCR equipment, and Mr. Shepard said there was no commercial reason to do this so no machine has been developed. Professor Benham asked whether hologram techniques have been applied to the character recognition field. Mr. Shepard said not to his knowledge commercially, and he did not know how much in the laboratory. Professor Lawler reviewed some work being done at the University of Michigan and said several large corporations are interested. Brief mention was also made of the laser used in such work, its cost, and the expected rapid decline in cost of such units.

There was a short discussion of costs and economics of automatic reading. Mr. Shepard said the cost of the recognition itself was not so much of a problem. Mr. Rotkin recalled some studies he had completed about a year ago dealing with automatic reading for input to a mechanical translation system. Compared to human reading and typing out, the cost of the automatic reading was almost negligible. He found that the reading part of an automatic translation system could be realized at a few cents per page whereas the translation costs a few dollars per page. Low machine costs require high speed high volume utilization of the machine. Thousands of pages per day must be handled if unit costs as mentioned above are to obtain. Present day commercial machines can not be used economically to prepare material for a blind user at the rate the user can accept. They must operate many times faster producing an output which could later be used at a lower rate compatible with the human's requirements.

Professor Benham said the cost of the reading, even when done by a human, is not the big cost in the operation. The Library of Congress may spend about $250 to get a novel read onto magnetic tape and then spends about $3000 to distribute two or three hundred copies around the country. Dr. Murphy told of one of his professors who always referred to the "high cost of saving money." Even though current costs are high Dr. Murphy feels research expenditures in the reading machine field are justifiable, particularly when used in support of research on outputs for the blind, the area not explored in any depth by commercial interests. H is quite optimistic that commercially developed recognition means, and computers "resting from their other jobs, will one day usefully serve in systems for the blind.

Brother Albert initiated a discussion on appropriate outputs for the blind from a machine which has recognized the characters. Mr. Dupress said an easy solution is to use spelled speech though the speed here will be less than with ordinary speech. Mr. Rotkin mentioned the limitations with English for letter-by-letter systems /he was obviously thinking of the complex grapheme-phoneme transform in English and the reputedly simpler ones for many other languages/ and the better chances with other European languages.

/Your editor clearly remembers first-day statements by instructors of Spanish, German, French, and Russian who always emphasized, "This language is spoken exactly as she is written." In a few weeks of study exceptions in all these tongues crop up, but it is agreed English probably poses the most problems./ Mr. Hathaway feels that English is more phonetic than we tend to think, and that spelled speech is a system that violates rules of semantics.

Dr. Cooper remarked that if a language were written phonemically it certainly would simplify the problems of developing an output, but this would not alone lead one to an easy solution. He continued saying one could make a dictionary of English words which were spoken as written, and there are many of them, and then make up a message only of these regular words. If one then spoke this message by any letter-by-letter method he would have to put out a series of short syllables, one per letter. The result would not be speech. Speech and letters are different things. Professor Metfessel said he felt his spelled-speech letter sounds were integrated into speech by their process of generation, and that they did not differ so much from speech. Mr. Rotkin wondered about dealing with two or three letters at a time rather than with one in an aim to make use of letter sequence information of the language. Dr. Cooper said one might just as well go to words and have the output in plain English.

XI. USE OF THE TELEPHONE NETWORK

Mr. Shepard announced publicly for the first time that his company, Cognitronics Corp., has developed a means which would enable a blind person at a remote location to send an image of a page over telephone lines to a central location. Here it could be read back to him either automatically or by a human operator. Mr. Shepard arranged to demonstrate limited versions of both of these systems at this session, the central facility being at Cognitronics' plant in Briarcliff Manor, N.Y., the other terminal being at this meeting in the Veterans Administration Central Office, Washington, D.C. The system as shown can operate at about 40 wpm, but with some modifications should be capable of 120 wpm over local lines. The estimated cost for each scanner (the unit installed at the "remote" location) is between $2500 and $7000 with additional charges for the central service. Cognitronics Corp. could make initial deliveries of such units by mid-1966, volume deliveries late in the year. The present units accept only single sheets, but bound-page readers could be developed. Before demonstrating a working model which looked like a more-or-less conventional rotating cylinder facsimile device, Mr. Shepard showed a mock-up cover of an advanced model which looked more like an office copier. This cover had controls for initiating operation, for skipping material on the page, and for going back for a repeat. It also had provision for a visual or tactile indicator to signal if the central facility was ready to receive a transmission.

Mr. Shepard then proceeded to conduct his demonstration, pointing out this is the first time they have operated over long-distance lines. He showed the facsimile-drum-scanner rotating and said an ordinary piece of paper with three typed lines was affixed to the drum. The first two lines were numerals only, these to be automatically read at Briarcliff Manor. The third line, comprised of typed letters, will be read by a staff member at Briarcliff Manor who will receive the letter images on the face of a cathode ray tube. First the automatic numeral-reading phase was successfully demonstrated. Those present heard a voice from a Cognitronics Corp. "Speechmaker speak back over the phone lines the digits recognized from data sent in over the lines. When the scanner was on white paper it encoded that fact, transmitted it, and advanced the photosensitive scanning-head quite rapidly. When the head "hit" type much more information had to be encoded and transmitted. The head advance rate was automatically reduced during such higher information-rate intervals. The audience could hear clicks, more frequent during fast-pass over blank paper, less frequent as the alphanumeric data were being sensed and transmitted. Mr. Shepard said the head advance was 0.005" per click.

A demonstration of the second mode of operation was then conducted, an engineer at Briarcliff Manor correctly reading back a line of text he saw on a CRT face, the data for this tube-face image coming in over the lines from the drum-scanner in Washington. Mr. Shepard said the 0.005" resolution in both directions was quite adequate for the job. He was able to operate faster and with better resolution than ordinary facsimile over equivalent bandwidth lines because of his use of pulse code modulation.

Although the demonstration equipment here is limited to a line height of 0.140", this is just an arbitrary value related to a typewriter font used in the experimental development. There are no severe limitations on the size one could assign as the scanning area. Mr. Shepard then discussed briefly the pros and cons of the human operator or automatic recognition machine at the central office. He did not know how much importance people attached to privacy and impersonal service, and concluded that perhaps human readers as well as machines should be available and at the choice of the user.

Mr. Shepard said Cognitronics Corporation was ready to make a central-office telephone-connected reading system available in the New York area by Summer 1966 provided there were on the order of 20 customers. Many questions remain to be answered regarding the probable market, price suitability, and acceptability of the home-terminal units essentially in their present form. Cognitronics does not look for profit from such a venture, but cannot operate at a loss either.

Mr. Mauch inquired as to the price of the service to the 20 or more prospective subscribers in the New York area. Mr. Shepard pointed out that costs would depend on whether there were volunteers or paid people in the central office, whether existing equipment could be used in odd hours, or whether special equipment costing about $50,000 had to be amortized through service charges for this work alone. While Cognitronics' policy does not permit quoting prices without a written specification describing the item, Mr. Shepard said the home-terminal equipment would cost from $2500 to $7000 each, depending on complexity of the unit. Brother Albert computed that for a ten year life the terminal equipment might cost from $1.00 to $3.00 a day, a reasonably inexpensive item he felt for a person needing such service. Telephone company charges will also be involved, Dataphones of the kind used at this demonstration costing $40 a month. Mr. Shepard feels less expensive arrangements are technically feasible, and hopes perhaps preferential changes may be possible from the telephone companies, historically interested in problems of the communications handicapped. Mr. Smith wondered whether picture-telephones might not be in competition with the Cognitronics plan. Mr. Shepard felt not at present, but perhaps in the future as video transmissions over the telephone system get more and more commonplace.

Messrs. Benham, Mauch, Shepard, and Smith had a brief discussion of the use and costs of various facsimile systems as reading aids for the blind. Dr. Murphy reminded the group that Mr. Sherertz proposed such an idea at the Second Reading Machine Conference (1955), but added that it was never put into practice by anyone.

Dr. Murphy suggested the intriguing possibilities of a text transmission system for use between libraries and library readers. This could cut down on the time required to get a document from a distant library, and could ease space problems by permitting highly specialized collections in selected libraries arranged so duplication of holdings would be unnecessary.

Mr. Shepard again probed the audience with the question as to how important anonymity is in a reading system for the blind. No clear decision was reached by the group on this point. At present, Mr. Shepard said sighted volunteers at the central office would provide the cheapest system and could handle a wide variety of formats and type styles. In the future automatic systems may become economically competitive.

Mr. Dupress mentioned an existing system, perhaps the only one at this time, in Atlanta, Georgia, where a blind pupil can dial a 'phone number to reach a volunteer who will then read the current assignment to the blind child.

The discussion then swung back to one of economics and costs. Professor Benham considered the $2500 terminal cost plus line charges for operation much too high to be paid by more than a very few blind persons. Competition from volunteer readers or readers paid about $2.00 an hour looms large when considering the automatic or semi-automatic systems. In reply to a question from Mr. Mauch, Professor Benham said he would pay $25.00 to $30.00 a month on a trial basis for a "Phonovision" service assuming it were available. This would entail holding up the material to be read near the input "camera" in the person's home, and then listening to a distant reader read it back over the 'phone.

Mr. Rogers remarked that information about the Cognitronics equipment and plans should be published in places where it would reach a good cross-section of the blind population. He suggested articles in "The New Outlook for the Blind" and in the "Matilda Ziegler Magazine for the Blind." Via these two journals, one for professional workers in the field, the other for blind people in general, a diversified sampling of interested people would be reached.

Professor Benham then thanked Mr. Shepard for the trouble he and his firm had gone to to put on the very worthwhile demonstrations witnessed by those present.

XII. RECOMMENDED PROJECTS AND PRIORITIES

The chairman then moved on to the last principal order of business of the conference, a discussion of what should be done next, and with what priority. He considered first a study committee to review the work of Mr. Shepard with the aim of determining costs and specifications for a central-office and home-terminals system somewhat like he just described. Mr. Dupress interjected that we should not consider only a system like the Cognitronics', but rather a system having a variety of inputs and outputs, possibly having utility outside the blind community, and perhaps being the beneficiary of preferentially low night rates when used in service of the blind. He said his reading lag now with a $2.00 per hour reader often runs at 10-15 days, and an overnight delay or so should not be serious at all. Professor Benham persisted in testing the group's opinion as to appointing a study committee. There was no strong consensus for such a committee but the need for specifications and information on costs, capabilities, and limitations of the system was emphasized by Mr. Rogers. Mr. Smith started a brief discussion when he said perhaps a Visotoner or Mauch recognition machine could compete in the several-thousand-dollar class with the Cognitronics' plan which might have terminals and central facilities costing as much per subscriber.

Mr. Dupress referred to the remarks made earlier in the conference by Mr. Korb relating to time compressed speech. Mr. Dupress said there is no universally satisfactory rate for recordings for blind people. Some can use speeded-up materials, but others require things slowed below the original reading rate. The very elderly often can absorb more if the rate is slowed. Mr. Dupress felt work in compression and expansion should be pursued. /Editor's note: A conference on this subject was held October 19-21, 1966 at the Center for Rate Controlled Recordings, University of Louisville, Louisville, Kentucky 40208. A proceedings volume (45) edited by Dr. Emerson Foulke has since been issued. A news bulletin "CRCR Newsletter" contains current information about the field and is obtainable from the Louisville Center./

Mr. Freiberger noted that some communications people have been predicting great things for video over the telephone lines, perhaps to become commonplace in 5-10 years. He said that a system such as this, one used by and developed for the whole community, usable also as an aid for the blind, often turns out to be the very best kind of aid. Mr. Shepard said video over the telephone was a matter of pulse code modulation to improve bandwidth efficiency.

Professor Lawler noted there was a general principle involved in time-sharing an expensive central apparatus with many subscribers connected via the telephone lines. This mode of operation is burgeoning in the computer field and seems applicable and valid to systems for the blind. Professor Lawler also recommended work on an improved Visagraph-style machine to handle mathematical equations and symbols. Mr. Rogers suggested work on Professor Linvill's tactile device as a possible aid to meet the needs in mathematics and fields using many symbols. Mr. Smith said perhaps the Visotactor could serve here, and Mr. Freiberger suggested a process using conventional office copying machines, but with a special material, to produce almost instant tangible relief or rough-grained copies of ink-print originals.

Replying to the chairman's question as to when the next meeting in this series should be held, Dr. Murphy said, "... when something new is ready to be shown." Mr. Rogers thought communications in the field needed strengthening during the 2-3 year period before the next meeting. Mr. Freiberger pointed out he would be preparing minutes of the present sessions, and that much information appears in the AFB Research Bulletins, in "The New Outlook for the Blind," and in the VA "Bulletin of Prosthetics Research." Dr. Murphy also cited some information sources, mentioning the following reference items: (2), (22), (46), (47), (48), and (49).

Mr. Apple proposed that future work should include putting the Visotoner and Visotactor into the hands of an expert instructor who, in turn, would instruct some blind people in the necessary techniques. It is important that machines be manufactured in sufficient quantity that they be available, possibly on a lease or loan basis. Mr. Apple stressed the need to take the devices out of the laboratories of their developers and to put them in ordinary surroundings.

There was a brief discussion of reading embossed letters such as those made by the larger sized "Dymo" tape embosser. Professor Benham said he could read such raised letters, but not without study. He thought he could read at about 20-25 wpm. When the question of reading speed for facsimile raised letters came up, Mr. Rogers said existing old studies with Boston Line Type and Moon Type should provide much information without the need to conduct repeat experiments.

XIII. ADJOURNMENT

Referring to the lateness of the hour, Professor Benham, the chairman, thanked all present for coming and the Veterans Administration for making the meeting possible. Receiving the thanks of the group for serving as chairman, Professor Benham closed the conference a few minutes after 5:00 P.M., January 28, 1966.

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P-316 2/68

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